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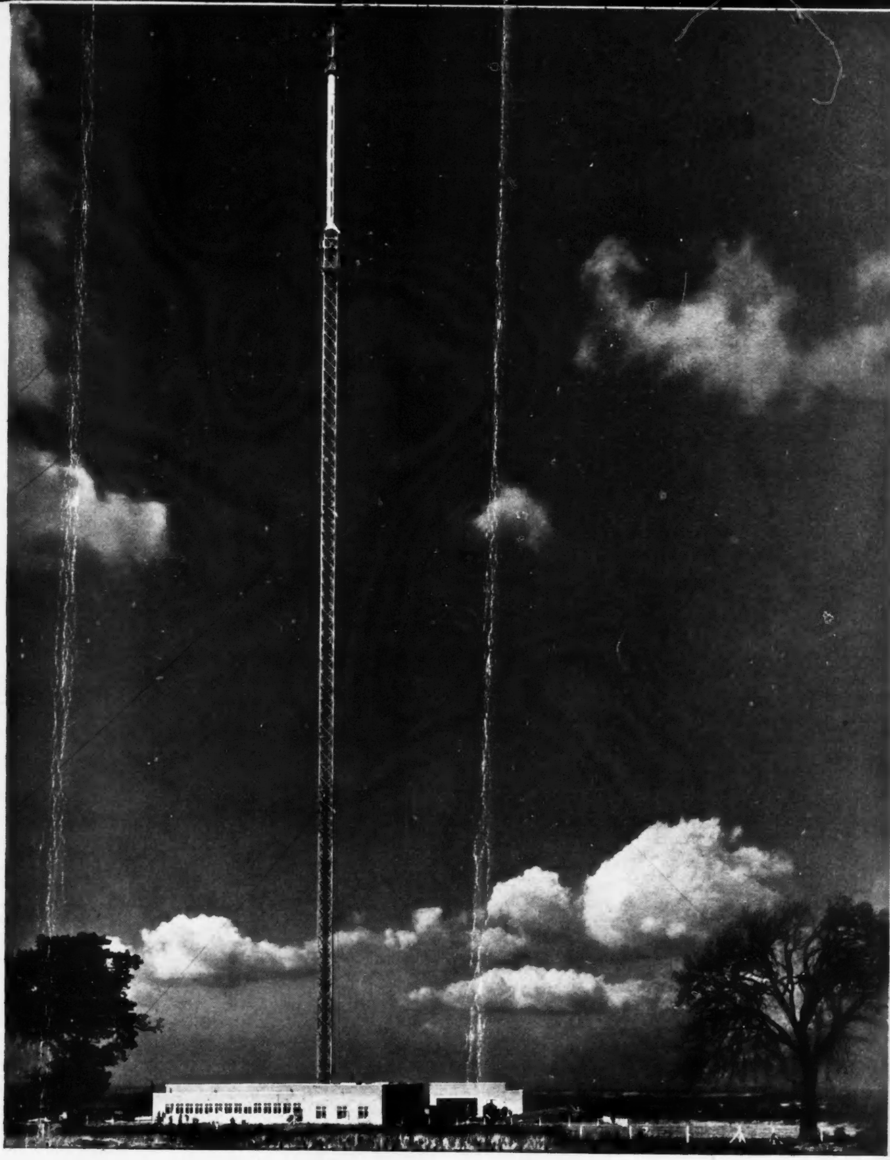

JANUARY
1950

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DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

January, 1950 Vol. XI. No. 1

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Editorial Office: 244 High Holborn, W.C.1. Tel. Chancery 6518
Advertisement Office: Temple Chambers, Temple Avenue, London, E.C.4. Tel. City 6537 (Three Lines)
All Subscriptions, Distribution and Business Communications to Jarrold & Sons Ltd., Norwich. Tel. Norwich 25261

The Progress of Science

A Scientist Investigates Dowsing

To disbelieve in some phenomenon that current theory is supposed to have established is a minor misdemeanour in the world of science. But to believe something which is inexplicable in terms of current theory is often regarded as a serious felony. This scepticism has been one of the corner posts of science.

In the opinion of S. W. Tromp, Professor of Geology at the Fouad University, Cairo, dowsing or water-divining provides an example of a phenomenon in regard to which scientific scepticism has over-reached itself. In a recent book, *Psychical Physics* (Elsevier Publishing Co., 1949), he sets out to prove that dowsing is a reality and that it is, in fact, no more than the reaction of certain hypersensitive people to perfectly ordinary physical forces, usually electric or magnetic forces.

A dowser holds a forked stick in his hands with a special grip. And the claim for dowsing is that when used by 'gifted' people this stick twists and turns in their hands when they approach water and ore deposits, as well as a great many other objects such as walls of houses and living bodies. Tromp dismisses the claim that dowsing can specifically identify, say, the presence of water, but believes he can prove that the dowsing reaction is real and is an indication of some physical cause in the environment, though the exact nature of that cause cannot be decided by dowsing only—just as a geophysical-prospecting instrument will not positively indicate a water-bearing stratum, but will indicate a discontinuity which, in the light of other evidence, might be identified as a water-bearing layer.

His main evidence is a series of experiments carried out in Holland in 1946 and 1947. In the first group of experiments a number of dowsers were subjected to the action of changing magnetic fields. They were blindfolded and unable to hear the operation of the apparatus involved in the experiment; and, in so far as one can judge from the description, the conditions were such as to prevent either conscious or unconscious cheating. The general upshot of the experiments was that whenever a magnetic field covering the body of the dowser was switched on or off, or substantially varied in strength, the dowsing reaction ensued—in other words, the stick twisted in the dowser's hands. It was also found that when dowsers explored buildings they frequently got positive reactions at places which were afterwards found to have strong magnetic anomalies. Other experiments (which appear to have been less thorough) indicate that dowsers are also liable to react to electrostatic fields.

In another group of experiments a technical trick was used to arrange that the divining rod did not turn. A string galvanometer was connected across the dowser's wrists in the way normally used to obtain an electro-cardiogram (i.e. a record of the minute electric current produced by the muscular action of the heart). After various control experiments, the dowser was set to walk through zones where dowsing reactions were normally obtained. It was found that in each case the electro-cardiogram showed, superimposed on the normal pattern of heart beat, a secular change in the potential across the wrists, thus indicating that some electrical change was taking place in the dowser's body. This happened both when walking through zones of magnetic anomaly in the laboratory and when driving in a car across a canal or other body of water. In these experiments it is not made clear what precautions were taken to ensure that the dowser was ignorant of what was happening. But assuming that adequate measures were taken, the experiments would seem to prove that in places where dowsers normally claim that their rod turns electrical changes do actually take place in their bodies.

On the basis of these experiments, together with experiments already reported by others and a very extensive survey of the electrical and magnetic properties of the human body, Tromp proposes the following theory of dowsing. In the neighbourhood of any object there are always certain fields of physical force—perfectly normal fields that do not go outside the range of established physics. These include, for example, electrical fields arising from charges on the object, or from a condenser effect between an earthed object and a charge on the dowser's own person. Or again they include variations in the earth's magnetic field produced by the magnetic properties of the object. Electromagnetic radiations, radioactivity, and even the volatile matter that causes smell, are not excluded, though no useful evidence is given for bringing them in. The human body can be shown in various ways to be a sensitive

detector of such fields (though it must be said that some of the cases accepted by Professor Tromp are open to grave doubt, for example that in which magnetic fields are said to have influenced the rate of cancer growth). Professor Tromp supposes that variations in these fields as the dowser moves in or out of them induce minute electric currents in some of his nerve cells and thus stimulate the nerves; the stimulus, amplified in the usual way in the central nervous system, is passed to the motor nerves of the arm muscles; the muscles contract and thus cause the rod to turn. The rod thus acts only as a pointer, and perhaps also as a means of allowing the dowser to set his muscles in unstable and sensitive positions. But the important happenings are normal nerve impulses and muscle contractions set in motion by currents induced in the nerves by the influence of external electrical and magnetic fields. Dowsers are specially gifted only in having a peculiar sensitivity—the electric effects are detectable in other people by the electrocardiogram, but do not produce muscular movement.

It seems to us that Professor Tromp's rather narrow range of experiments, even when backed by his comprehensive analysis of the work of others, are not sufficient to establish his theory. But they do obviously indicate that there is much to be investigated.

"Science Survey" Reaches its Century

THE treatment science receives in radio programmes seems to have improved considerably in the last few years, and doubtless there is some connexion between this and the representations made to Broadcasting House in 1945 by a delegation of scientists which urged the case that science demanded greater attention on the air. Nevertheless, it can still be argued that in relation to its importance to the community, or in relation to the actual proportion of social activity that is devoted to it, science has consistently received a disproportionately small allocation of time, compared with, say, music or even musical criticism or literary criticism.

There is, for instance, only one regular science feature in the evening programmes—"Science Survey". This, however, is now firmly established and its producer, Dr. Archie Clow, is to be congratulated on this series of talks which reached its century last month. This programme is most useful to the general class of laymen with some scientific education—including on the one hand, people who have learned some science because they feel that it is an essential part of a liberal education, and on the other hand school-teachers, administrators, and the like who come in contact professionally in various ways with science or with its fruits. "Science Survey" shows every sign of being immensely valuable to such people in their efforts to keep abreast of the flood of research. It must also be very helpful to the scientific specialist who wants to gain some general idea of what is happening outside his own field. The programme is heard by at least a million people, which is a measure of its success in making scientific subjects clear and intelligible to a large public.

London's Starlings

EVER since, some fifty-five years ago, starlings began to fly into London every autumn and winter evening to roost instead of out into the suburbs and rural districts, naturalists have been asking where the birds have come from. It was natural at first to suppose that since the habit was a new one the starlings could not be the ordinary London ones, but must be from the Continent. But this idea, while theoretically attractive, has not yet been made to fit with the known facts. Indeed, such facts as are known point in the other direction. This winter the Ornithological Section of the London Natural History Society is engaged in a ringing experiment to try and ascertain where the starlings that spend the autumn and winter in Central London are to be found in the breeding season.

Leaving aside the current experiment, the known facts about the migration of starlings and their relation to the London roosts are fairly suggestive. As long ago as 1925 E. M. Nicholson was able to prove that the starlings that roost in London do not, as had been supposed until then, feed by day in huge flocks on outlying playing fields and sewage farms, but are scattered over the whole suburban area within ten or twelve miles of Charing Cross, and gradually collect into small parties and increasingly large flocks as they fly towards the City and West End, gathering fresh members as they go. Moreover it is known that the main influx of Continental immigrant starlings to the British Isles occurs between the end of September and the beginning of November, while so far as numbers can be counted it seems that the London roosts attain pretty well their full strength before this influx begins. What is impossible to say, however, is to what extent Continental birds may take the places of British ones later in the winter. It is known that some British starlings roost in their breeding holes from January onwards, but it is impossible yet to be sure that sufficient numbers do so in the London area for their places in the central roosts to be taken by substantial numbers of Continental immigrants without having any effect on total numbers. A further confusing factor is that starlings tend to move southwards within Great Britain in the autumn, and it is not yet known at what date most of them return northwards. The inquiry at present being conducted into the breeding biology of the starling by Dr. R. Carrick of Aberdeen University may throw light on this among other dark places.

The whole question of starlings roosting on buildings has been insufficiently investigated. While starlings have always roosted on coastal cliffs where appropriate ledges were available, and still do so, especially in the north of Scotland, the story of their colonisation of building roosts in large cities other than London has never been told in detail. When B. J. Marples undertook a nation-wide survey of starling roosts in 1932–33, roosts, most of them on buildings, were reported in the following large towns in addition to London: Barnsley, Belfast, Birkenhead, Blackpool, Bradford, Dublin, Edinburgh, Glasgow, Leicester, Liverpool, Manchester, Newcastle-on-Tyne and Swansea. More recently starlings roosting on buildings in the centre of Birmingham have become such pests that attempts—apparently singularly unsuccessful—have been made to scare them away by supersonic devices. In London the habit of roosting on buildings seems to be about thirty-five years old, having begun some twenty years after the starlings began to roost in trees in the centre of the city. Today the whole of the City and the West End is one vast starling roost, the birds using both trees and buildings

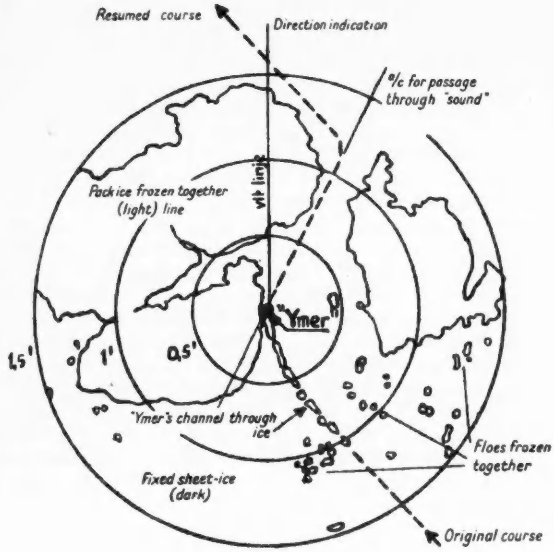


FIG. 1.—The experience of the ice-breaker *Ymer* proved the value of this kind of radar picture in navigation through ice floes. Pack-ice shows up white; the smooth ice-sheets, which are more easily negotiated, are black. The ship (at the centre of the picture) left a trail of rough ice behind it, clearly seen on the radar screen as a line of white blobs. (*By courtesy of the Institute of Navigation.*)

indiscriminately, though there seems to be a definite tendency to transfer from trees to buildings as the autumn progresses. Within the inner built-up area the birds are liable to shift from one group of buildings to another in much the same way that they sometimes shift from roosts in the country. Of course, by no means all buildings in the City and West End are used as roosts at any one time, there being definite foci, such as Trafalgar Square in the west and Finsbury Circus in the east. The investigation of the London Natural History Society is covering also this aspect of the starling problem in London, and it is hoped to discover when and why starlings transfer from trees to buildings, as well as to measure the fluctuations in the total population from one end of the season to another.

REFERENCES

Fitter, R. S. R., *London's Birds*. London, 1949.

Marples, B. J., "The winter starling roosts of Great Britain", *Journal of Animal Ecology*, 1934, Vol. 3, p. 314.

Parrinder, E. R., Letters in *The Listener* (8.9.49), and the *New Statesman and Nation* (22.10.49).

Radar Aids the Ice-breaker

THE ice-breaking ships that cut channels for convoys in the frozen north are not, on the whole, greatly concerned about smooth unbroken ice-fields. These are generally fairly new formations consisting of comparatively thin ice which is easily dealt with. A far more serious obstacle is provided by solidly frozen pack-ice, produced by a break-up and second freezing of the original smooth fields. When the heaving of the water breaks up the ice, it forms blocks with rectangular faces. These may be forced over one another, echelon-fashion, to form a thick layer, and then frozen firmly together again. It is this frozen pack-ice that really delays the ice-breaker. It is much more difficult to break, and even when it is broken the channel is likely to be filled with a mass of loose floes which will impede the following ships.

It is not easy for the look-out on an ice-breaker to see which kind of ice lies ahead, as the ice is quite likely to carry a snow covering, and in any case arctic weather conditions usually include poor visibility. Now radar has come to the rescue. Radar pulses are not reflected by the smooth ice-fields, so that these appear dark on the radar screen (even darker than open sea, which gives at least some reflections from waves). But the angles between the rectangular blocks of the frozen pack-ice form almost ideal radar reflectors, so that these more troublesome fields show up on the screen as white patches. A moderate covering of snow, provided it is loosely packed, does not shield the ice surface from the radar and so does not obliterate the distinction.

Experiments on a Swedish ice-breaker, the *Ymer*, have shown that radar can be used in this way to improve greatly the performance of the ice-breaker. Fig. 1 shows a case in which the *Ymer*'s course would have taken her directly through large patches of pack-ice with consequent difficulties and delays. The radar observation enabled her to make a short detour which avoided the pack-ice, and so cut out the delay.

By similar means it has been found possible to pick out channels of open water, and to detect drifting ice-floes in open sea. And naturally radar has also proved valuable in determining position and in supervising the convoys that follow the ice-breaker.

REFERENCE

Hugo Larsson, "The Use of Radar in the Ice-breaker Service", *Journal of the Institute of Navigation*, October 1949, pp. 315–22.

The Dolphin and the Whale

WHAT looks to be the final solution of the problem of the dolphin and the whale, subject only to later refinements in figures, was given by Prof. A. V. Hill in a recent lecture to the Royal Institution, London. The problem is in two

parts. The first is the 'paradox', as it has been called by Prof. James Gray of Cambridge University, that the horse-power of either or both seems inadequate to account for their observed speed. The resistance to their motion seems to be less than that which is encountered by an inert object moving through water, and scientists, particularly those with experience of ship-tanks, are now searching for a trick of movement which could make the water flow more smoothly past their bodies than is the case with an inert object. From this point of view—as a paradox of horse-power and movement—it has been generally supposed that the dolphin, as the smaller animal, would present the more difficult case; although there is little, if anything, in terms of speed to choose between them. Either can cruise for long periods at around 15 knots, and produce shorter bursts of the order of 20 knots or a little over. The second problem, which particularly interested Prof. Hill, is that of the scale relationship between the two animals which, being similar in shape, differ in linear dimensions by a factor of more than 10.

Taking the case of the dolphin first, Prof. Hill both described observational evidence and developed a theoretical argument. The observational evidence came from Mr. G. A. Steven of the Marine Biological Station, and was the result of his war-time service in corvettes. In this capacity, he many times watched the approach at night of both dolphins and seals under conditions when their course and the movement of the water was marked by phosphorescent protozoa which emit light on being stirred or touched. With a dolphin, there was only a thin line of light, with no sign of turbulence; with a seal, useful as a control, there was a large amount of turbulence which could be easily seen. It seems therefore that a dolphin really can propel its 6–8 ft. length through the water at a speed of 15 knots with a form of flow which on visual inspection appears wholly smooth.

Most earlier discussion has been based on the argument, used by Prof. James Gray of Cambridge, that the horse-power which an animal can develop would be proportional, at least roughly, to the weight of muscle which it possesses. Instead, Prof. Hill looked to the heart as a limiting factor: for, however great the weight of muscle, the greatest sustained horse-power which the animal can obtain from it can be no greater than the rate of oxygen supply to its tissues will permit.

Prof. Hill took the case of a 6·6 ft. dolphin weighing about 180 lb. and swimming at 15 knots, and pointed out that 0·22 h.p. would be required for wholly smooth flow, but 1·6 h.p. if flow were wholly turbulent. But in relation to body weight, the hearts of dolphins, whales and men are in about the same proportion—0·5% in each case. For an athletic man, the maximum sustained output of energy is about 0·35 h.p. This figure was, therefore, about as high as could reasonably be applied to a typical but slightly heavier dolphin going about its normal business.

It would imply that flow was smooth over at least nine-tenths of the dolphin's surface; and even this would tax its athletic capacity 'pretty high' and leave little enough in hand for the 'joyous bursts' at higher speed of which it seems capable. Thus far, therefore, observations and calculation agree well.

Prof. Hill's greatest originality, however, was in his treatment of the blue whale—the largest species of whale—as a dolphin on a larger scale. He developed a number of arguments to show that, as between similar animals, sustained horse-power should be approximately proportional to surface area and not to volume or weight—as would be the case if weight of muscle and horse-power are taken to be in proportion. Two of these arguments were based on the heart; another, more general, on the greater strength of tissues which would be required if driving pressures were to be exerted at the same frequency in the larger animal.

The first of his arguments based on the heart considered the pressure which would have to be exerted by the heart if a volume of blood, which is proportional to body weight, has to be driven through an outlet pipe, the aorta, the cross-section of which is proportional to surface area and not to volume, in the case of animals of different size but similar proportions. Taking two animals, one of which has linear dimensions 10 times as big as in the other, the blood in the larger animal would have to travel 10 times as fast at the peak of movement, and the pumping pressure of the heart would have to be 100 times greater. Such a situation would imply that the pumping pressure of the whale's heart would need to be 2–4 atmospheres, which is clearly absurd for the animal's tissues could not stand up to such a pressure. Alternatively, the rate at which blood is pumped from the heart can be considered in terms of the volume delivered at each movement and the rate of heart-beat. The volume can be assumed proportionate to heart-size which, as already mentioned, is approximately to scale as between whale and dolphin. A basis for the heart-beat rate is suggested by a general relationship put forward by the late Prof. A. J. Clark to express numerically the slower heart-beat characteristic of larger animals; this would give the 100-ton blue whale a heart-rate about 8 times slower than the 180-lb. dolphin. Instead of the increase in horse-power of 1240 times, which might be expected on a basis of weight, the increase would be limited to one of 154-fold by the slower heart-rate. But a figure of 0·35 h.p. has been admitted for the dolphin—and is supported by observation to the extent indicated—so that the power available for the whale should be about 54 h.p. At the same speed of 15 knots, the whale should require 9 h.p. with wholly smooth flow, but 160 h.p. with flow wholly turbulent. Prof. Hill concludes, therefore, that for an 84-ft. whale, cruising at 15 knots, flow must be smooth over the forward two-thirds of the body, and that this, too, is "an engineering feat of considerable interest". However, Prof. Hill's own interest, as already implied, was in the scale relationship. The advantage of the dolphin and whale for this purpose is that, with their weight supported by water, they are immune from the usual complication that an increase in size implies a disproportionate increase in the thickness of supporting limbs with further consequential effects which, if the difference is large, destroy the scale relationship. For that reason, it is perhaps a little unreal to talk of similar land-living animals of different size. With this qualification, Prof. Hill drew the generalisation that warm-blooded animals of similar form, and 'designed' with a similar factor of safety, should be able to run and swim at the same speed and to jump the same height.

The Adrenal Gland

GEOFFREY H. BOURNE, D.Phil., D.Sc.

In the year 1882 a controversy about the adrenal gland appeared in the pages of the French scientific press. Nearly fifty years before, an Italian scientist, Dr. Della Chiaje, had claimed that the adrenal glands were known to Moses, and were mentioned in the Bible. In defence of this statement he quoted several passages from the Latin translation of the Vulgate in which there were references to 'ren'—kidney and 'renunculis' which latter, Della Chiaje claimed, meant 'small kidney' or 'adrenal'. It was Professor Blanchard of France who in 1882 contested this statement. First, he said, Saint Jerome was not renowned as a man of letters and secondly that the actual translation had in any case not been made by him but had been carried out under his direction. Blanchard decided to inspect the original Hebrew text of the Vulgate and there he found two words 'kelayot' and 'hakelayot'. The first of these means simply 'kidney', the second 'the kidney'. This second word had been translated by Saint Jerome as 'renunculus'—so here was in fact the mistake upon which Della Chiaje's claim rested.

It would have been very interesting had it been a fact that the adrenal glands were known to Moses because it had been accepted that these glands were discovered by Bartholomeus Eustachius in 1563. It is surprising that the remarkable physiological and anatomical schools set up by the Greeks at Cos and Alexandria hundreds of years before the birth of Christ did not discover the adrenals. The liver and the sex glands seem to have been known since the earliest times and even such glands as the thymus and the pineal and the thyroid were well known by the early part of the Christian era. There is just a chance that the Roman Historian, Pliny, may have seen the adrenals for he says that on one occasion, dissecting a sheep, he saw four kidneys (two of these may have been adrenals).

Eustachius, who finally recorded the presence of these glands, was a professor at the Collegio della Sapienza at Rome and he worked for many years on a series of forty-seven engravings on copper plates illustrating the anatomy of the human body. The last plate was finished in 1552 and they were all then placed in the Papal library in the Vatican, but it was not until 1563 that he actually published an account of the adrenals which he called 'Glandulae renibus incumbentes'.

In 1714 Pope Clement XI gave the copper plates prepared by Eustachius to his medical attendant, Lancisi, who published them with his own descriptions. The publication of these illustrations, some of which figured the adrenals, put the glands, so to speak, on the map. They had been referred to, however, by Jean Riolan in 1629 as supra-renal (meaning on top of the kidney) capsules. This is a good name for them in human beings because they do sit on the kidneys as little cocked hats. In other animals the glands lie near the inner surface of the kidneys and are more accurately described as 'adrenals'.

The adrenals figured in the medical press in France again in 1716. In that year the Academy of Sciences at Bordeaux decided to hold a prize essay competition on "What is the use of the adrenal glands?" A well-known author of the day, Montesquieu, was appointed judge of the essays. Being a man of subtle wit, he had a lot of satirical comments to make on the essays submitted. Perhaps his best comment was on the views of an author who said that there were two kinds of bile; a grosser one which was separated out by the liver and a more subtle one which was secreted in the kidneys and which passed to the adrenals by ducts of which we were ignorant. The dry comment by Montesquieu on this claim was that we were menaced with perpetual ignorance of such ducts.

A most important discovery about the functioning of the adrenals was made by Thomas Addison in 1855 who found that in patients who had died from the fatal disease which became named after him, the adrenal glands were almost completely destroyed by disease. In many cases this disease was tuberculosis. This was the first indication that the adrenal glands might be necessary for life. His report stimulated considerable research on the function of the adrenals and a young man of American-French extraction called Brown-Sequard removed adrenal glands from animals and found that they died. He was attacked for his conclusions that the adrenals were thereby necessary for life by the French Academy of Sciences because it was said that the serious operation necessary to remove the glands was the real cause of death. Later workers then showed that it was the outer layer of the gland, the cortex, and not the middle part (medulla) which was essential for life.

At this point it will no doubt be of interest to describe the structure of the adrenals. In human beings the glands measure about 5 centimetres by 3 centimetres and are about one centimetre thick. The two glands together weigh between $\frac{1}{3}$ and $\frac{1}{2}$ oz. In shape they are triangular and are perched on the top of each kidney looking rather like cocked hats. If one of the glands is cut in half, it can be seen to be made up of an outer paler portion and an inner dark red portion. The former is the cortex and the latter the medulla. It is only in mammals that these two tissues have come together to form such a typical organ. In birds, snakes and lizards, frogs and newts they have come into contact with each other but they are in the form of isolated groups of cells, mixed up together. In the fishes, however, the tissues are widely separated. The tissue which is equivalent to the cortex of the mammalian adrenal in the form of a large solid mass is situated between the two kidneys whereas the equivalent of the medullary tissue is scattered as small paired bodies in the body wall on either side of the backbone and in association with certain nerve ganglia. This fact enabled a number of workers at the end of the nineteenth century to carry out experiments on the importance of the cortex for life. Small sharks were used for the experiments and the mass of intra-renal tissue was removed. The sharks recovered from the operation quickly and for two or three days seemed normal. Then they became inactive, would not eat, and continuing to mope this way they finally died seven to fourteen days after the operation. Other workers then showed that by cutting away the cortex from the adrenals of mammals the animals died in about the same time. On the other hand if the

medulla was destroyed or scraped (with an instrument called a curette) out of the gland there was no apparent ill-effect.

Adrenal Hormones

It was obvious from these experiments that the cortex contained or produced something which was essential for life. This information had been obtained early in the present century, but during the century before, in 1856, Professor Vulpian of France had shown that the medulla of the adrenal gave a green colour with ferric chloride. He made an even more important observation than that for he found that the blood going into the adrenal did not give a green colour with ferric chloride but that the blood coming away from the gland did. So, he argued, the adrenal medulla must discharge something into the blood. This was the first experimental evidence of what is called 'internal secretion'. The idea of such a process had, however, been first uttered by Théophile de Bordeu, a fashionable French physician, in 1775. It might be as well to divert here for a moment to describe the difference between 'internal' and 'external' secretion. Some glands in the body, e.g., the pancreas, the salivary glands, etc., discharge their secretions into a tube or duct which empties them on to a surface of the body (e.g., the salivary ducts discharge the secretions of the salivary glands on to the surface of the mucous membrane lining the inside of the mouth). This is 'external' secretion. In 'internal' secretion there is no duct and the products secreted by the cells are discharged direct into the blood which filters between them. Glands which discharge the products of their activities in this way are known as 'internal secreting' or 'endocrine' glands. The products of such glands are called 'hormones' or chemical messengers. Since Professor Vulpian had found that some substance which reduced ferric chloride was apparently discharged into the blood stream by the adrenal medulla, this seemed to establish that tissue as an endocrine gland. The really big step forward in the development of our knowledge of

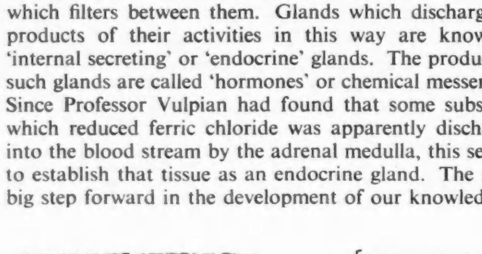


FIG. 1.—Two early drawings showing structure of adrenal gland; published by Prof. Eberth in 1872. (*Left*) Section through horse's adrenal. (*Right*) Section through human adrenal.

1. Cortex. 2. Medulla.

a. Capsule. *b.* Outer cell layers. *c.* Cell strands (zona fasciculata). *d.* Inner cell strands. *e.* Medullary substance. *f.* Vein in cross sections.

'internal secretion' occurred, however, in 1894 when Oliver and Schafer in Edinburgh made saline extracts of the adrenal medulla and injected them into experimental animals. One can imagine the excitement among the experimenters as the apparatus used for indicating the level of blood pressure of the anaesthetised animal showed a sudden increase. Oliver and Schafer had in fact proved, not only that the adrenal medulla passed some chemical substance into the blood stream, but that this substance had a physiological effect, i.e., it increased the blood pressure. This work was an outstanding land-mark in the history of Endocrinology. Then in 1901 Drs. Takamine and Aldrich independently isolated this active substance from the adrenal medulla and were able to work out its chemical formula. It was called 'adrenalin' and before long it was synthesised and was readily available for a variety of therapeutic purposes. Later it was found that the active principle of the Chinese drug *Ma huang* known from antiquity as a haemostatic (substance which prevents bleeding) was closely chemically related to adrenalin; it was named ephedrine and it, too, took its place in therapeutics alongside adrenalin.

In medicine adrenalin is used in a dilution of about 1 part in 1000 parts of saline. It is used to stimulate respiration or to encourage a heart, which has stopped, to beat again. It prolongs and enhances the effects of certain local anaesthetics such as cocaine and therefore finds an important use in this field. By contraction of the small blood vessels it reduces bleeding and is thus used for the treatment of haemorrhage. It gives relief to sufferers from asthma and helps the recovery of patients suffering from a form of allergic shock that sometimes accompanies the injection of sera and is known as serum sickness. It is obviously therefore a most useful and valuable drug.

Adrenalin has a number of functions in the body. It causes contraction of the peripheral capillary blood vessels; it speeds up the action of the heart; it causes contraction of organs such as the spleen, which is a reservoir of blood and the contraction of which, therefore, results in more blood going into general circulation; it causes the liberation of sugar into the blood by the liver, thus providing readily available energy from the tissues; it stimulates the secretion of thyroxin from the thyroid gland which increases the pace at which the body's vital machinery works, and so on.

The effects of adrenalin are, therefore, the effects of emergency. If you are frightened and you want to run, the physiological equipment for running faster than you have ever run before is made available for you by the anticipatory secretion of adrenalin. If you are angry and you want to fight, the same emergency physiological equipment will help you hit harder and last longer than normal.

But none of these functions are essential for normal life; that is why the medulla can be removed without serious effects—but what of the mass of solid cords of cells between which the adrenal blood slowly trickles and filters on its way to the medulla—what of the cortex surrounding and enveloping the medulla like a mysterious shroud? The first world war came and went and the enigma of the cortex remained unanswered. Addisonian patients sickened and died. Facts were found out about them. For example, they excreted excessive amounts of salt in their urine; they could be given a precarious existence sometimes

for a little while, sometimes for a long while, by copious drinks of salty water, but always the cortex sat like a Greek Sphinx asking its riddle of all who tried to pass. The 1920's saw the solution of the problem. Drs. Rogof and Stewart in America set to work to remove the adrenals from innumerable cats and dogs and tried to keep the adrenalectromised animals alive. One by one other laboratories in America started to work on the same problem. Dr. Frank Hartman was another recruit to the field. Drs. Swingle and Pfiffner also joined in the attack, but still the adrenal cortex kept its secret. Then in 1928 Dr. Hartman was successful; he prepared an extract of the adrenal cortex which would keep adrenalectomised animals alive. Swingle and Pfiffner were not far behind and by 1930 a number of potent extracts of the gland had been made. However, vast quantities of glands were needed for a very small amount of potent extract and although this was already being used to keep alive human patients suffering from Addison's disease it was still hoped that the active material might be isolated, chemically identified and perhaps synthesised. At this time there was an argument as to the nature of the fundamental physiological change underlying deficiency of the cortical secretion. One school of thought believed it was an upset of the mechanism for conserving salt and water in the body, another believed it was primarily an upset of the metabolism of the sugars in the body. In 1936 and 1937 Professor Reichstein and his colleagues in Switzerland isolated a number of chemical substances from the adrenal cortex. One of these was called 'desoxycorticosterone' and was shown to be the 'salt and water' hormone. Another substance was 'corticosterone' which was shown to be a 'sugar' hormone. So both the dissentient schools were right. There was a third substance isolated by Reichstein which had some activity as a sugar hormone: it was called 'dehydrocorticosterone'.

The interesting thing about all these cortical hormones was that they belonged to a group of chemical substances known as sterols—a group to which most of the sex hormones belong. Subsequently some twenty-eight different sterols were isolated from the adrenal cortex and only some five of them could, on injection, improve or bring back adrenalectomised animals to normal. Some had activity similar to that of the male sex hormone. There is a curious connexion between the sex glands and the adrenal glands. It has been known for many years, for example, that the adrenals of a female were heavier than those of the male and that at the oestrus or heat period of the female the gland is bigger and heavier than at the non-heat period. Professor Zuckerman and the present author showed in 1941 that the sexual cycle of the female appeared to be controlled by the adrenals. Earlier work had shown that if the adrenals of a pregnant animal were removed it did not develop symptoms of adrenal insufficiency until a structure in the ovary, which always accompanies pregnancy, the 'corpus luteum', disappeared. In 1938 it was shown first by the present author and later by Dr. Gaunt in America that the hormone of the corpus luteum, known as progesterone, could keep animals deprived of their adrenals alive. It has also been shown that progesterone has a close chemical similarity to the hormones of the adrenal cortex. Another interesting fact concerning the

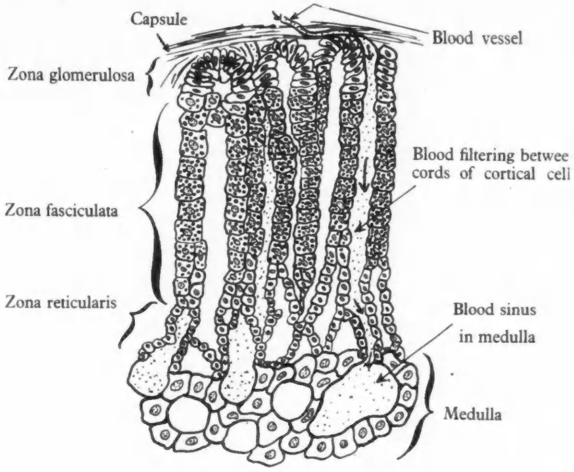


FIG. 2.—The adrenal gland in section. Arrows show the course of the blood as it filters through the cortex to the medulla. The three zones labelled on left have different functions. The zona glomerulosa probably produces the salt-and-water hormone; sex hormones are thought to be produced by the zona reticularis, and hormones concerned with sugar metabolism by the zona fasciculata.

relationship of the adrenal cortex to sex and reproduction is the fact that Dr. L. R. Broster in this country has shown that in women (particularly young ones) who start to show male sex changes such as deepening of voice, growth of hair on the face and so on, one of the adrenals is often enlarged, and if it is removed by operation the changes regress. Later it was found that in such cases there was increased excretion of sterol substances having male sex hormone activity, into the urine. So the cause of the trouble here may be due to the excessive production of male sex hormone by the adrenal cortex. The full relationship between the sex hormone and the adrenals has yet to be worked out.

In 1939 desoxycorticosterone was synthesised and it was used for treating human patients suffering from Addison's disease. Then it was found that the hormone, instead of being continuously injected into the patient in an oily solution, could be compressed into tablets and inserted under the skin. One tablet inserted in this way lasts many months.

So we have unlocked many of the secrets of the adrenal cortex but apparently there are still more to come. The recent discovery in America of the importance of Reichstein's third compound—dehydrocorticosterone—in the treatment of rheumatoid arthritis has been hailed as a discovery second only to that of insulin. What more has this remarkable tissue to offer us? Its control over our lives is certainly an important one and although it has taken us 400 years to get so far, it is certain we are not yet at the end of the secrets of the adrenal cortex.

Trace Elements and Plant Growth

D. P. HOPKINS, B.Sc., F.R.I.C.

How many of the chemical elements are indispensable in the nutrition of plants? Once we imagined that we knew the complete answer to this. Open almost any book on agricultural chemistry dated between 1850 and 1920 and in some part of the text it will probably be stated that ten elements and no more than ten are essential plant-foods. This was one of the 'laws of life' which nineteenth-century scientists felt sure they had established. We know more about plant nutrition today and one of the results is that we can be certain about rather less.

The conception of elements as plant nutrients was originated by Liebig in 1840 when he put forward his revolutionary theory of mineral nutrition. Formerly it had been supposed that plants drew their food somewhat mysteriously and even mystically from humus. Liebig contended that the elements found when plants were analysed were their necessary foods and that soils supported crops well or badly insofar as they contained adequate or inadequate supplies of those elements. Some of his ideas on plant nutrition were entirely incorrect; for example, he assumed that plants drew all their nitrogen from the air and not from nitrogen compounds in the soil. As for his central assumption that every element found in a plant was *ipso facto* essential to its life and growth, this would be considered too sweeping a generalisation today.

The ten-element conception must be mainly attributed to the widespread use of solution culture for growing test plants in post-Liebig research. It followed from Liebig's main principles that a plant should be able to grow if its roots were not in soil but in a solution containing the required nutrient elements. When this was indeed found practicable, a convenient method for studying plant nutrition was provided. It soon became the general opinion that a solution would support normal plant life and growth if it contained *seven* elements—nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, and iron. When one of these was omitted, growth was unsatisfactory. On the other hand, the addition of other elements did not seem necessary. The remaining three of the 'essential ten' were carbon, hydrogen, and oxygen, which were readily derived from the carbon dioxide of the air (by photosynthesis) and from the water of the soil or nutrient solution.

It should not be supposed that these successive generations of agricultural scientists were slapdash in their methods of investigation or sophistic in their thinking. Though they did not realise it, the methods of analysis employed in their time were not sufficiently sensitive to recognise the parts played by other elements needed in much smaller amounts. Their nutrient solutions, carefully prepared though these were, contained more elements than they supposed. What we know now to be the trace elements were present as incidental impurities—impurities in the salts used, in the water used, and even impurities derived from the equipment used, e.g., copper was usually present in traces derived from the metal vessels used in preparing distilled water. The presence and effect of trace nutrients could not be appreciated until the trace quantities in solutions could be detected by improved methods of analysis. As long as these conditions prevailed, the ten-element 'law' remained a fixture of orthodox thought; and the longer it was unquestioned, the more established it became.

Solution culture was not the only method of studying plant nutrition. Increasingly large numbers of direct soil-growth tests were being conducted; tests in pots, on small plots, and even in sizeable fields. Some of the soil-test practitioners were influenced by Liebig's suggestion that any element found in a plant may be assumed to have been essential to its nutrition. In this kind of work, too, they were less handicapped by contemporary standards of analysis. They could analyse the mineral ashes from an appreciable number of plants; the amounts of trace minerals present were the total sum of traces in all the plants and not just the minute trace of impurity in a small jar or bottle of dilute solution. In the analysis of soils and plants they found a wider range of elements than the academic 'essential ten'. From the eighteen-nineties onwards many experiments to determine whether these additional elements could assist cropping took place. Evidence was often conflicting, but on the whole it indicated that more than ten elements were beneficial to plant growth.

Early Work

It is often stated in authoritative accounts of this subject that trace elements were not recognised until 1914 and not generally recognised until about ten years after this date. This is not wholly true, and for the sake of fairness to some of the earlier workers it is worth while to mention some of the first papers. From about 1895 onwards the position of copper as a plant nutrient or plant poison was frequently investigated, mainly because copper salts were widely used as plant fungicides. While copper in large amounts was proved to be toxic (indeed, to be useful as a weed-killer) at least one early paper—from Tokio in 1904—showed that copper in small amounts exerted a favourable influence upon crop growth and yields. Another Tokio paper of 1904 showed that manganese could increase rice yields; and in France there were papers in 1905 and 1906 by Gabriel Bertrand emphatically claiming that manganese was an essential plant nutrient. Indeed, French scientists seem to have been well to the fore in this kind of research, for in 1907 Javillier published evidence showing that zinc could play a useful part in plant nutrition, and Agulhon reported in several 1910 papers that boron compounds were successful fertilisers in small applications. A survey of the early literature shows that by 1910 the favourable effects of copper, manganese, zinc, and boron had been demonstrated quite clearly in field experiments; moreover, it had been shown that these favourable effects were produced only if the applications were small.

Meanwhile, the more academic exponents of the solution culture method seemed unimpressed. It was suggested that if other elements could assist plant growth, they acted as 'stimulators' but were not really essential. In 1914 a French scientist, Mazé, used the solution culture method

itself to shake this fixed opinion. Using very highly purified chemicals, Mazé prepared solutions which should have been completely adequate for plant growth according to prevailing ideas on the elements essential to plant growth. His solutions contained impurities, it is true, but only in minute quantities. He found that his very pure solutions did not support plant growth satisfactorily, and he concluded that more than ten elements must be regarded as essential. But Mazé's important paper was given little attention. Its date may be the real reason for its neglect; most soil scientists were soon to be plunged into the short-term problems of war.

Not until the early twenties was Mazé's work to be followed up, principally in America. In 1922 McHargue of the Kentucky Research Centre, published an impressive amount of evidence for the role of manganese as an essential plant nutrient. (He had in 1914 shown that manganese was present in the seed coats of various seeds.) With nutrient solutions so carefully prepared that manganese impurities were absent (or at least only very insignificantly present), McHargue showed that plant growth stopped after a few weeks; but when it was present in only small amounts plant growth proceeded normally. By this time methods of analysis had become sufficiently sensitive to control the trace contents of dilute solutions; but it should be realised that the strength of McHargue's case for manganese rested almost entirely upon the reliability of the analytical methods. This, then, was not a case of ten little niggerboys becoming nine, but of ten becoming eleven.

Far more important than the establishment of manganese as a trace element was the principle which was established by McHargue's work. Tests with culture solutions had to be preceded by the most sensitive operations of inorganic chemical analysis. To judge whether or not an element was an essential plant nutrient, solutions must be prepared from which even minute amounts of the specific element had been withheld or removed. By 1926 the California Experiment Station had become a centre for specialised research of this kind. There it was established that boron was an essential trace nutrient for all species of plants tested. By 1931 the Californian school, led by Lipman, had also proved that copper and zinc were essential trace elements. During the twenties there was at least one British contribution, though perhaps of limited significance; at Rothamsted it was established in 1927 that boron was an essential element for beans.

During the early 'boom' in this subject of research there was a good deal of confused nomenclature. There was at first a general tendency for these four 'new' elements and at least four of the original ten to be called 'minor elements' or 'secondary elements'. Nitrogen, phosphorus, and potassium were regarded as *major elements* because plants required these in relatively large amounts and soils frequently became seriously deficient in available supplies. By contrast, but rather unwisely, the other elements were grouped together as *minor elements*—magnesium, calcium, sulphur, and iron of the long-recognised group, and the newly recognised manganese, boron, copper and zinc. This, to say the least, was a loose and unworthy piece of scientific classification. Magnesium, calcium, and sulphur were certainly needed in far from minor quantities; if soil shortages of these elements did not occur as often as those

FIG. 1.—Hollow centre and internal rotting of a cauliflower symptomatic of boron deficiency. (*Photo: Dept. of Agriculture & Stock, Brisbane.*)

of nitrogen, phosphorus, and potassium, it was because they were better provided in many soils and because they were regularly added to soils as 'incidentals' of other operations, e.g. calcium in lime and many phosphatic fertilisers, magnesium as an impurity in potash salts, and sulphur as a substantial ingredient of such fertilisers as sulphate of ammonia and superphosphate. Also, the term 'minor' or 'secondary' implied that these nutrients were of lesser significance to plant growth, a totally wrong impression whether they were needed in fair amounts or only in traces. The absence of any one of them could cause not merely minor ill-effects but major catastrophe to plant growth. Today few scientists speak of minor elements. Nitrogen, phosphorus, potassium, calcium, sulphur, and magnesium are called *major elements* since they are required in relatively large amounts. Those elements which are essential in minute amounts are called *trace elements*, or sometimes 'micro-nutrients'. Iron seems to stand in an intermediate position; the iron requirement is not so large that it can be called a major element, yet it is hardly so small that iron can rank as a trace element.

Some idea must be given of the actual amounts of these nutrients which plants seem to require. In nutrient solutions the necessary concentrations of trace elements will range from as little as two or three parts in 100 million up to a few parts in 10 million. These amounts are so fantastically small that sceptics may be tempted to argue that the whole subject is an exaggeration of science. However, the concentrations of even those elements needed in larger

FIG. 2.—Apple foliage showing intervenal chlorosis, due to manganese deficiency. (*Photo: Long Ashton Research Station, by courtesy of FARMING.*)

amounts are quite small by ordinary standards of solution strength, and the minuteness of trace element quantities must be judged against a general background of great dilution. For example, a fertiliser solution for application to pot plants would not contain more than 1 part of nitrogen in 10,000 parts of water. Even so, the ratio between amounts of trace elements and amounts of major elements required by plants will lie roughly between 1 : 1000 and 1 : 10,000. In soils, however, quantities are somewhat larger. To maintain a specific concentration in the soil solution (the soil's moisture), considerably more of the nutrient must be present in the soil itself. In rectifying deficiencies of trace elements in the field, suitable compounds containing these elements are usually applied at the rate of a few pounds per acre. Such rates may be compared with applications of fertilisers providing nitrogen, phosphorus, or potassium at rates of a few hundredweights per acre. However, the comparison is not really as straightforward as this suggests. The trace element dressing might cure the deficiency for a number of seasons while the major nutrient fertilisers would be needed each year or for each successive crop. In the soil this matter of amounts of nutrients is also complicated by questions of availability and non-availability. Any guide to actual quantity needs must, therefore, be regarded as very rough.

Since such small amounts of the trace elements are required, it might seem unlikely that soils should ever be unable to provide enough for all crops. Yet it is a fact that in the past ten to fifteen years increasing numbers of serious deficiencies have been recognised. In some large agricultural areas of the world—particularly in Florida, U.S.A., and in certain sandy areas of Australia—economic cropping would have probably ceased but for the diagnosis of a trace element deficiency and subsequent remedial treatment.

Practical diagnosis is based upon recognising symptoms similar to those developed from the artificial deficiency produced in refined solution cultures. No attempt can be made in this article to list the various symptoms. Naturally these vary for the different trace nutrients; but for the same nutrient they are also variable for different crops. There is an excellent British account in Professor T. Wallace's book, *The Diagnosis of Mineral Deficiencies in Plants*; and there is also a valuable American book, *Hunger Signs in Crops*. It need hardly be said that the recognition of trace element troubles in crops calls for a good deal of specialised experience.

Trace element shortages are not always induced by a real absence of the particular element in the top-soil. A large supply may be present but it may be 'locked up' as a result of soil conditions and thus unable to enter the soil solution and become available to plants. Severe zinc deficiency effects upon fruit trees in America were experienced although the soils contained enough zinc for the whole orchard's needs for a hundred years. Even the addition of zinc salts to this soil could not correct the deficiency for the added zinc was also quickly made non-available; but very dilute solutions of zinc sulphate sprayed on to the foliage of the trees cured the malnutrition. Another approach has been the injection of solid salts containing a trace nutrient into the trunk of the tree. The spraying method often has to be used when deficiency is due to non-availability; that means that whereas chemical analysis shows that the soil contains a fair quantity of a particular element the conditions are such that the element is not available to the plants which cannot absorb it in sufficient amounts. Manganese deficiency, which is now known to occur in many parts of England and very severely in Florida and much of the Atlantic coastal plain of the United States, is generally due to non-availability rather than to actual absence of the element. On the other hand, boron deficiency, which severely affects many different crops, is usually due to boron absence, for borates are easily washed out of sandy soils. Here the remedy of applying boron compounds to soils is effective. So far significant zinc and copper deficiencies have not been reported in British soils but in America and Australia there have been numbers of examples. In Australia cereal cropping at an economic level could only be established on sandy plains after correcting the initial zinc deficiencies with zinc sulphate application.

Correcting Deficiencies on the Farm

Some consumption figures will show how much the practical study of trace element deficiencies is expanding in the United States. Until the late thirties, boron was scarcely used at all as a fertiliser; by 1945 an annual use of 3700 tons of borax had developed, and by 1948 an estimate was made that the amount used was approaching 10,000

tons. Copper sulphate as a soil application rose from nil to 12,000 tons per annum in ten years; in the same period the use of zinc sulphate had climbed from nil to 3000 tons annually. In the second world war manganese sulphate use more than trebled in the United States, rising to over 20,000 tons per annum; about half of this tonnage was used in Florida alone. These figures have since increased. One reason for the increase is that more and more land has become deficient in trace elements, intensive cultivation having exhausted the supplies of these elements originally present in the soil. Another reason is the increasing American use of very concentrated fertilisers for providing major nutrients; for high concentration inevitably means that the 'impurity content' of other nutrients in these fertilisers will be less.

Since in most cases the remedial applications are fairly small—rarely above a few pounds per acre—it might seem sensible to make these applications a regular farming practice and so insure against the development of deficiencies. But we have not yet discussed one of the most surprising and awkward features of trace elements—that, although they are essential in minute amounts, they soon become toxic to plants if the 'beneficial rate' is exceeded. This is particularly true of boron. The consensus of present opinion among British soil and fertiliser scientists is that trace element applications should be given separately as and when expert diagnosis has shown them to be needed. In the United States, however, many fertiliser manufacturers already incorporate trace elements in their compounds; but there a manufacturer generally produces for a known region and the trace element deficiencies are more or less regionalised. The problem, both from the production and application angle, is simpler by being a problem on a much larger scale. In America the deliberate addition of trace elements to mixed fertilisers is likely to increase; but in Britain it is a practice that may probably never even start.

Some fertiliser materials always contain trace elements in any case; for instance, Chilean nitrates contain boron and basic slag contains manganese. Superphosphate contains slight amounts of copper and zinc derived from the sulphuric acid used in its manufacture. Supplies of trace elements from this source go some way towards correcting deficiencies of trace elements.

Trace Elements and Plant Physiology

Readers may well ask, why are such trace quantities of these elements actually needed by plants? What happens to them inside the plant?

One theory, which has followed not unnaturally from the fact that mere traces are effective, is that these elements are not really direct plant-foods but that they act as catalysts or regulators of vital chemical processes. This point is made clearer by contrasting this kind of nutrient action with that of magnesium. Magnesium atoms are found in every molecule of the green pigment of plant foliage, chlorophyll; and chlorophyll is an essential substance of plants because it plays a big part in the photosynthesis by which they derive carbon and energy. Magnesium is, therefore, a 'direct' plant-food—it has to be assimilated for the manufacture of more and more chlorophyll as the plant grows. But if boron is mainly needed as a regulator for certain plant reactions but not as an ingredient of important plant substances, it is understandable that much smaller quantities of boron than those of magnesium will suffice for their respective tasks.

Manganese, too, is believed to be associated with chlorophyll manufacture, and in this catalytic function it seems to be also associated with iron. Copper may be a catalyst for plant reactions involving oxidation, while zinc is believed to be a catalyst for the synthesis of plant proteins. But all this is speculation. Light may be thrown upon the functions of trace elements when their movements in living plants can be followed by the use of their radioactive isotopes.

So far boron, manganese, copper, and zinc have been mentioned. There is a fifth to be added to the list of trace elements—molybdenum. Experimental proof that this element was essential was published by Californian workers in 1939; today molybdenum's trace essentiality is generally accepted. In field conditions, however, molybdenum deficiencies have not yet been seriously encountered.

To date, then, we have five trace elements whose right to be called essential is proven and accepted. But we cannot add our new knowledge to that of the nineteenth-century scientists and say now that there are fifteen essential elements for plants and no more than fifteen. The door must be kept open for further additions to the list. Hoagland, a leading American authority on the trace elements, has summed this up admirably: "One can say about almost any chemical element that appears not to be essential only that it is not required in greater quantity than is represented by the unavoidable impurities in the culture solution."

Another provoking aspect of this subject can be found in the duality of many elements as both plant and animal nutrients. The plant world cannot be considered in isolation. It is a bridge between the inert mineral world and the living organic world. Most of the minerals needed in plant nutrition are also essential for animal nutrition, e.g. calcium, phosphorus, iron, magnesium, etc. Yet in what seem to be otherwise admirably planned natural arrangements, there are some strange anomalies. Cobalt and iodine are essential elements for animal nutrition, but all attempts to prove that these elements are essential trace elements in plant nutrition have so far failed. In several parts of the world including Britain cobalt sulphate applications must be made to grassland in order to overcome serious cobalt deficiency diseases in animals. Boron has been proved to be essential to plants but there has been no definite proof that it has any functions in animal nutrition. It is very tempting to assume that anomalies such as these are no more than symptoms of our own ignorance; just as the gaps in Mendeléef's Periodic Table were for a long time no more than tokens of our inability to isolate the missing elements.

READING LIST

The Diagnosis of Mineral Deficiencies in Plants, (H.M.S.O., 1943), T. Wallace.

Some Elements of Plants and Animals (Fertiliser Journal Ltd., London, 1948), F. E. Corrie.

Inorganic Plant Nutrition (Chronica Botanica Co., U.S.A., 1948), D. R. Hoagland.

Bibliography of the Minor Elements, 1935–1947 (Chilean Nitrate Educational Bureau).

Hunger Signs in Crops (American Society of Agronomy, 1949).

Experiments with Mosquitoes

FIG. 1.—Breeding mosquito larvae at Horton Hospital. The larvae live among the partially submerged grass; nourishment is added to the breeding pans in the form of dried yeast and algae.

AT least a hundred thousand mosquitoes are reared in Britain each year for the maintenance of malariatherapy alone, and since many times that number are required for research purposes throughout the world, the anopheline mosquito is under constant surveillance and has been made the subject of much experimentation.

It was Von Jauregg, the Viennese psychiatrist, who discovered that a stiff jolt of malaria arrested the course of General Paralysis of the Insane, the disorder of advanced syphilis, and at the Horton Hospital for Mental Diseases, near Epsom, Mr. P. G. Shute has the care of the descendant generations of a batch of mosquitoes (*Anopheles maculipennis* variety *atroparvus*) originally collected in 1926 for that purpose. Patients are infected with malaria directly by the mosquitoes and during the course of the fever they provide the necessary blood food for a new batch of virgin mosquitoes which can then be used both for the infection of other patients and the maintenance of the Horton strain of some thousands of directly related generations.

The insects develop in a row of shallow earthenware pans, 300 in each, in an external insect-house. Narrow slices of grass sods immersed in the water provide the necessary food for the larvae, together with the addition of a little dried algae, and the adults so bred compare favourably in size, length of life and voracity with specimens in natural conditions.

At a normal temperature of 75° F. the life-cycle is completed in sixteen days (this is cut down to ten days with more heat), and the female adults lay batches of eggs, each egg being provided with a characteristic ridged float, at least once every four days. In summer they require very little attention; in winter the females tend to go into a state of semi-hibernation, but gravid insects can be persuaded to lay by close confinement near a little water.

At the beginning of 1948 Prof. H. E. Shortt and Dr. P. C. C. Garnham, of the London School of Hygiene and Tropical Medicine, reported the presence of a new cycle of the malaria parasite in the liver of a rhesus monkey (see DISCOVERY, May 1948: "Malaria, a Momentous Discovery"). It had not previously been known what happened to the organism during its cryptic stage—that is after it left the peripheral blood supply within an hour of injection by the mosquito. It now seemed reasonable to suppose that the hiding-place of the elusive sporozoite had at last been tracked down. To confirm the assumption it was decided to infect a human patient with malaria, and as a small section of his liver would then have to be excised for examination, he had to be given a very heavy infective injection to ensure that just a few of the malaria organisms would be detectable.

Ten thousand mosquitoes were assembled for the experiment. Half of them were bred at Horton and also at the London School of Hygiene and Tropical Medicine; the rest were collected from cowsheds and pigsties in Kent and Essex. *A. maculipennis* is so highly domesticated that it is not difficult to bottle a thousand from one out-house. They are picked up, thirty at a time, in an inverted tube which is calculated to mutilate fewer specimens than the use of the pooter or sucking tube.

The infecting technique, for details of which the author is indebted to Mr. Shute of Epsom, was to place eight jars, each containing fifty mosquitoes, against the leg of the patient between thigh and knee. Four jars were placed on each leg so that 400 mosquitoes were being used at the same time. The jars were held in position for approximately half an hour and then returned to the insect-house. There they were released into a cage and, by the aid of diffused light, each mosquito was examined to ascertain whether or not it had ingorged blood. Those which had fed were put into a suitable cage and the unfed ones were kept on one side for feeding on the following day.

On the first day 1744 mosquitoes fed, the work beginning at 7 a.m. and ending twelve hours later. Feeding continued the second day, when the total number of mosquitoes fed and sorted numbered 3600. Throughout the following twelve days and nights, whilst the parasites were completing their life-cycle inside the mosquitoes, rabbits were kept in their cages to provide blood meals. Sporozoites were found in the salivary glands for the first time on the fourteenth day.

Much the same technique for infecting the patient whose liver was to be subsequently examined was used as that for infecting the mosquitoes. The infection covered a period of forty-eight hours. On the first day the patient was bitten by 1510 mosquitoes over a period of about nine hours, and on the second day by a further 500 mosquitoes, making a total of 2010. As usual, many mosquitoes punctured the skin several times before taking a meal, which meant that the actual number of bites was much greater than the actual counts as recorded by the presence of blood in the insects' stomach. The patient's

by JOHN D. HILLABY, F.Z.S.

reaction to this part of the test has not been recorded further than that he was "a willing volunteer".

To ensure the greatest intensity of infection the mosquito bites were supplemented by injecting the crushed salivary glands of 200 of the infected insects, 100 on each of the two days on which the patient was being bitten. By this means it was calculated that a further 9,000,000 sporozoites were injected intravenously. Two workers prepared the mosquitoes for dissection by taking off the legs, wings and heads, whilst two others carried out the actual dissection in saline solution. The glands were crushed beneath a paraffined cover glass and removed to a watch glass containing human blood serum.

As is now known, the experiment was wholly successful. The special form of parasite was found inside the liver cells: it divides into at least 1000 germs which escape into the blood and cause the typical fever.

Before this discovery, Mr. Shute was approached by Dr. H. Foy, a physiologist, with the suggestion that it might be possible to bombard malaria-carrying mosquitoes with gamma rays from radioactive phosphorus (P22) and then, after infecting a patient, they could perhaps track the sporozoites round the patient's body with a radio-sensitive counter. Several hundred insects were irradiated and their glands dissected. But none of the patients treated developed malaria. It was found that the insects were capable of withstanding a degree of irradiation proportionately much higher than similarly treated mammals, though if the insects could resist the bombardment the parasites apparently could not, and the experiment was eventually abandoned in the face of Shortt and Garnham's discovery.

A not dissimilar experiment, though for a very different purpose, was conducted at the Yaba Yellow Fever Research Institute in West Africa, where Dr. Bugher and Miss Taylor devised a technique for putting radioactive 'tag' on the insects in the larval stage. By such means they hoped to be able to obtain 'labelled' adults which could be released, identified after capture, and so give reliable data as to range of flight, size of mosquito population, and so on. Activated phosphorus and strontium were introduced into the breeding tanks of *Aedes aegyptii*, where it was mostly absorbed during the fourth larval instar. Like the Horton experiment, a high ratio of tolerance was observed with deleterious effects only on the egg-laying capacities of the females. Activated insects were released at various points, and a few were recaptured along a chain of trapping stations from nine to twenty-eight days after emergence. The wind was shown to have been responsible for much of the distribution from the point of release, although some progress had been made by wing-power alone.

Today, induced variations in natural populations have been obtained by the addition of yeast to the water in which larvae are reared, and also by the manipulation of the salinity and acidity of their habitat. This work, initiated by Heitz and Bauer, may eventually unravel some of the complexities of biological species.

Identification of some mosquito species can be difficult, as the differences separating one species from another may be rather obscure. Some workers use the differences in the chromosome pattern in cells of the salivary gland for identification purposes; others use the differences in the character of the wing scales.

FIG. 2.—Mr. P. G. Shute, entomologist at the Horton Hospital, looks at the pig in the insectarium which provides the adult mosquitoes with their meals of blood.

Of a more novel nature is the selective trapping technique of Offenhauser and Kahn, also of the Yellow Fever Research Institute. They discovered that the hum of mosquitoes is characteristic in both sex and species and, presumably, guides the male to the female. The germ of the idea goes back as far as 1901, when Sir Hiram Maxim wrote a letter to *The Times* in which he recorded that whilst installing a dynamo at Saratoga Springs he had noticed that the hum of the commutator had attracted many male mosquitoes but few females. The latest research has shown that the high-pitched 'pinging' call-note ranges over fifteen different frequencies with vibrato effects and changes in pitch with time. Female notes were generally more steady and lower in pitch than the male, although the pitch differences may be due to a different blend of harmonics.

A recording was taken of the hum of *Anopheles albimanus*, a malaria vector in Cuba, and by repeating the call-note over and over again from a disk, Offenhauser was able to send out the attracting call from an electrically charged wire trap. The experiment took place at intervals before sundown and the results were compared with a catch from a normal (cattle-baited) trap. Time analyses showed that it was most effective just before total darkness, when insects swarmed in to investigate the irresistible call in far greater numbers than those which came to the control trap. It remains to be seen whether characteristic calls can be used to attract other species.

Peripatus: A Missing Link

R. P. HILL, B.Sc., D.I.C.

In certain of the West Indian islands, in the year 1825, the Reverend Lansdowne Guilding discovered a new species of animal. It was quite small—between one and three inches in length—and it lived in all manner of damp and dark places. Its curiously aimless way of moving about prompted him to name it *Peripatus* and, misled by its slug-like antennae and by its moist skin, he classified it with the shell-less Molluscs, despite its many pairs of short, stumpy legs. It is beyond doubt that the Rev. Guilding upheld the doctrine of Special Creation: to him *Peripatus* was just another species, created when all other species were created. Today, ironically enough, we view his discovery in exactly the opposite light Although it is now placed in the great Phylum Arthropoda, together with crabs, lobsters and shrimps (Crustaceans), spiders and scorpions (Arachnids), centipedes and millipedes (Myriapods), and all the Insects, it shares many important characteristics with the earthworms, marine worms and leeches that make up the Phylum Annelida. It thus constitutes evidence for the evolutionary theory that the Arthropods are of Annelid descent. And its value as evidence is immeasurably increased by the virtual certainty that *Peripatus* has persisted without major change for several hundred million years. *Peripatus* is one of the very few creatures that may be described both as a 'Living Fossil' and as a 'Missing Link'.

Guilding's classification of *Peripatus* soon became a subject for dispute among those who followed up his work and dissected the animal. A few, arguing in one direction from the structure of the nervous system, agreed with Guilding that *Peripatus* was a Mollusc. A few others disagreed with this interpretation of the nervous system and thought it indicated a relationship with the Flat-worms (Platyhelminthes). But the main body of the disputants fell into two groups; those who believed *Peripatus* to be an Annelid worm, and those who regarded it as an Arthropod related to the centipedes. This controversy was hotly maintained by both sides until 1874 when Moseley finally gathered *Peripatus* into the Arthropod fold by proving the existence of a tracheal respiratory system—an internal system of branching air tubes found in most terrestrial Arthropods. At first *Peripatus* was placed with the centipedes in the Class Myriapoda; then, as the great differences between it and all other Arthropods came to be recognised, it was awarded a class of its own—the Class Onychophora. Initially, therefore, the Onychophora included nothing but the various species of *Peripatus*, which numbered about sixty.

Later, however, these species came to be divided among several closely related genera. The species appearing in our photographs is now known as *Peripatopsis moseleyi*.

There are certain fundamental differences between Arthropods and Annelids. The chief of these are concerned with the type of blood system, the position and structure of the heart, and the nature of the chief body spaces. And on these counts there is no doubt that the Onychophora are Arthropods. But there are also certain fundamental similarities. In both groups the body is segmented; that is, it is divided transversely into a number of sections each of which is in some respects self-contained. Thus each segment may have its own pair of limbs, its own muscles, excretory organs, subsidiary blood vessels, nerves, and sometimes even its own reproductive apparatus. Of course, since the animal has to function as a whole, certain structures such as the gut, the main blood vessels and the central nervous system will pass through all segments. In the Annelids, which are the more primitive group, this segmental repetition of organs is most marked. In the more advanced Arthropods it is less marked, although a segmental arrangement of the limbs is retained (Fig. 2). The normal Arthropod limb, however, is jointed and may be modified to serve other functions than locomotion. There is also a tendency in Arthropods to fuse blocks of segments together to form main body regions. This happens to a slight extent in Annelids where usually the first two segments unite to form the head. In Arthropods there may be up to seven head segments (Fig. 1). In all these respects the Onychophora more closely resemble the Annelids—a fact which emphasises their extreme primitiveness as Arthropods.

Peripatus and its allies are found in rotting timber, under stones and decaying vegetation, and sometimes in the nests of termites. Because of their retiring habits, their susceptibility to drought and their intolerance to any but the dimmest illumination they are difficult to observe and, in consequence, our knowledge of their life-history is still incomplete. They possess a pair of slime glands which open just behind the mouth on the oral papillae. When alarmed they eject this slime with considerable violence in the direction of the disturbance, and so sticky is this secretion that creatures larger than themselves can become hopelessly entangled in it. Usually this slime-spitting is followed by retreat and is held by one naturalist to be a purely defensive mechanism. Others have suggested, however, that it may be used to entrap and immobilise other small Arthropods—insects and centipedes for instance—on which the Onychophora appear to feed. In captivity they will feed readily on moribund or freshly killed specimens of various species but will not touch a carcase more than a few hours old. Like other Arthropods, Onychophora undergo ecdysis (cast their skins) and invariably eat the cast skin.

Although the body may be longitudinally contracted when at rest, Onychophora always move with it fully extended, using the legs rhythmically after the manner of a centipede. The sexes are separate; fertilisation is internal, and the male deposits packets of spermatozoa (spermatophores) everywhere on the body of the female, the sperm travelling by an unknown route to fertilise the eggs in the ovary. In some species the eggs are heavily yolked, are provided with a shell, and are laid. This conforms with normal Arthropod practice. Most Onychophoran species, however, bring forth their young alive—a specialised feature of the group which is typical neither of Annelids nor of Arthropods. (This viviparity has a feature in common with mammals; in a few of these viviparous species the egg is virtually yolkless and a placenta is formed.)

The evidence considered so far, while showing that the Onychophora are linked with both Arthropods and Annelids, gives no indication of their age as a distinct group. They might, for example, be a fairly recent offshoot of the Annelida whose evolution chanced to parallel to some extent those earlier lines of Annelidan evolution that gave rise to the other classes of Arthropoda. Only if it can be shown that they are a truly ancient group can their claim to true primitiveness be fully supported. Because of their soft bodies and their terrestrial habit, positive proof of age in the form of a long fossil record is unfortunately lacking. In fact the only known fossil that at all closely resembles *Peripatus*—and the resemblance is quite striking—is that of a marine Annelid or Arthropod found in mid-Cambrian rock laid down between four and five hundred million years ago. Nevertheless their age can be inferred from evidence of another kind. A new type of animal will arise in one particular locality. If successful it will spread radially outwards from its point of origin unless halted or deflected by topographical, climatic or other barriers. In general, therefore, an older group will tend to have a wider geographical distribution than a younger one. If at a later date this old group has to face competition from a younger and more efficient group it will be driven even further outwards. If it survives at all it will usually be found in isolated places such as islands which were early separated from the main land masses or possibly towards the extremities of the main land masses themselves. The present distribution of the Onychophora fulfils this specification exactly. Small colonies of distinct but closely related genera and species are found in the following places: West Indies, Central and Tropical South America, Chile, the Congo, Capetown and Natal, Malaya, New Britain, Southern Australia and Tasmania, New Zealand. From such a distribution we are entitled to infer that the Onychophora are indeed an ancient group.

From this and other evidence it is possible to reconstruct the probable course of events. In pre-Cambrian times the seas were full of soft-bodied, segmented, worm-like creatures which, were they alive today, we should be compelled to classify with the Annelida. In many respects they were primitive compared with the marine worms of today yet many of them showed characteristics possessed by no modern worm—characteristics which, in a more developed form, we now associate with other phyla. It is in fact probable that all the more advanced phyla arose in this way. In the early Palaeozoic some of the 'arthropod-worms' underwent a fairly rapid specialisation, giving rise to a race of armoured creatures called Trilobites that lie very nearly on the line of ascent of the modern Crustaceans and Arachnids. Others remained relatively unspecialised, an example being the mid-Cambrian *Peripatus* previously mentioned. Some of these unspecialised forms spread from the seas to the rivers and lakes and thence to the land, becoming the first terrestrial Arthropods if not the first terrestrial animals. These creatures looked very much like *Peripatus* and there can be little doubt that the general definition of the Class Onychophora would have embraced their chief characteristics. In other words, they were Onychophora and it was at this point that the group came into existence. They were able to exist out of water because they had developed a tracheal respiratory system, the tracheae having scattered openings as have those of modern

FIG. 1a

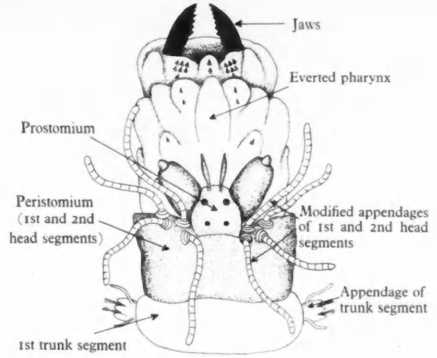


FIG. 1(*a*).—HEAD OF A MARINE WORM (*Nereis*) from above. It consists of the two segments of the peristomium which lie behind the mouth. The prostomium, bearing eyes, tentacles and palps, is not a true segment. The head is drawn with the pharynx everted to show the jaws, which are not modified appendages.

FIG. 1b

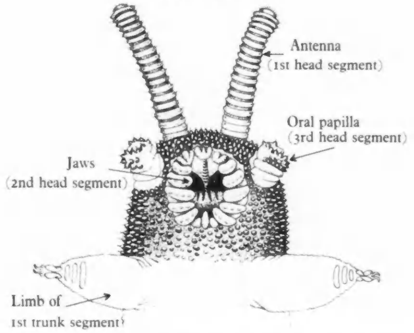


FIG. 1(*b*).—HEAD OF PERIPATUS from below. It consists of three segments; one in front of, and two behind, the mouth. The antennae are the appendages of the first segment, the jaws of the second and the oral papillae of the third.

FIG. 1c

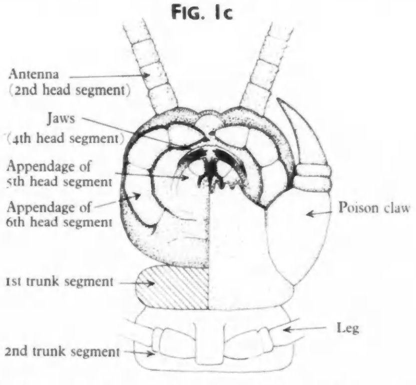
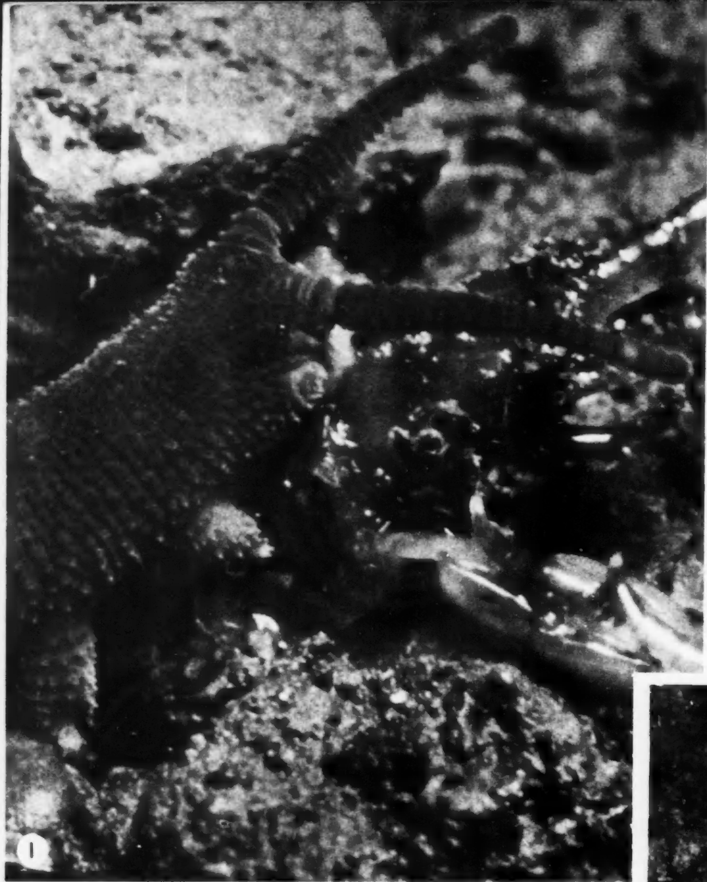


FIG. 1(*c*).—HEAD OF A CENTIPEDE (*Lithobius*) from below. It consists of six segments, three of which are in front of the mouth. The first segment (not seen in the drawing) bears the eyes; the second segment bears the antennae; the third segment can be traced only in the embryo; the fourth segment bears the jaws; the fifth bears the maxillules and the sixth bears the maxillae. The poison claws are the modified appendages of the first trunk segment.



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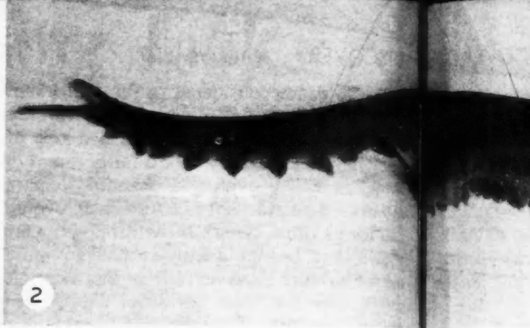

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2. Two specimens of *Peripatopsis*, rest with the b
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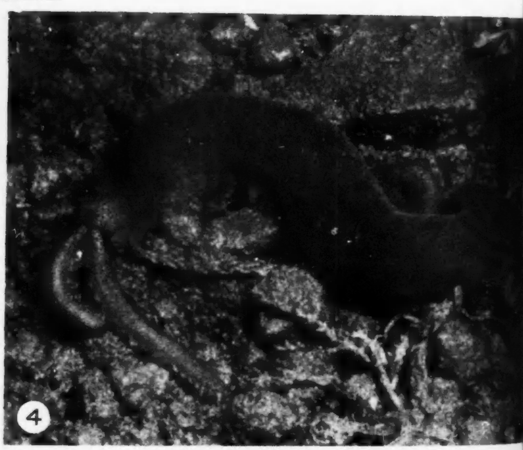
3. The animal, having ejected severa of slime, is in t
in order to retreat nd the nearest c

6, 7, 8.—*Peripatopsis* casting its skin. A split appears in the old skin on top of the head and this extends down the back towards the hinder end as the front end of the creature wriggles free. In the last photograph the animal has turned and commenced to eat the cast skin.



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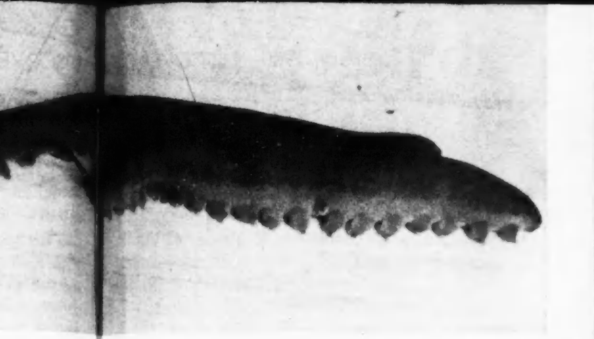


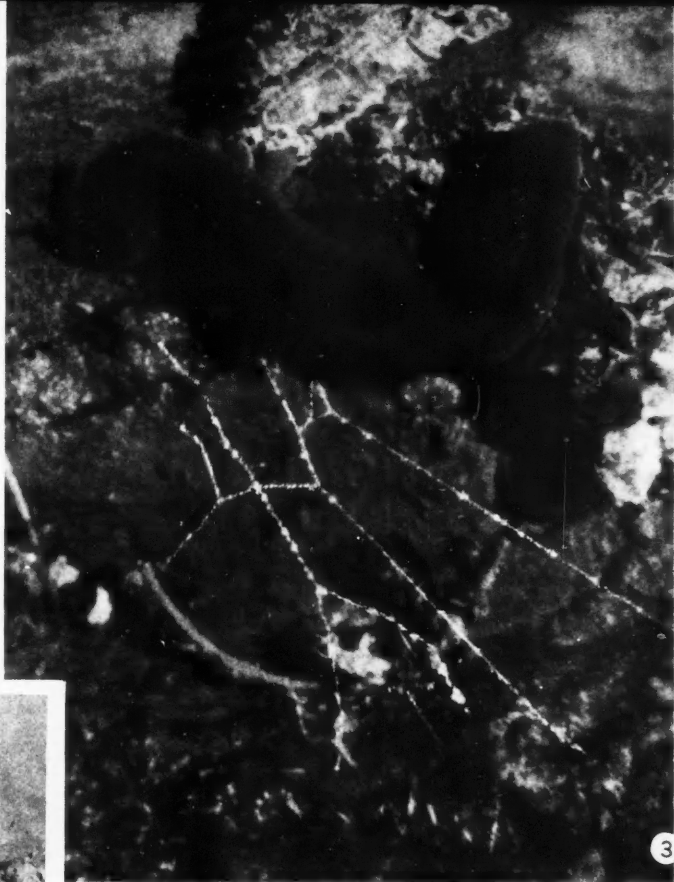
OF ERIPATOPSIS

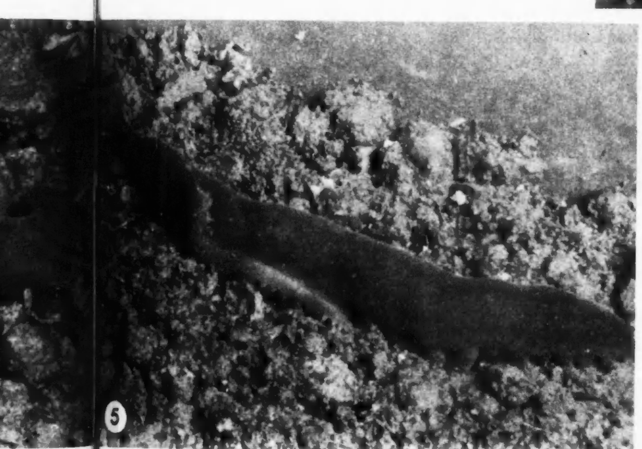
naking a meal the mangled body of a centipede.

Peripatopsis, at rest with the body contracted and the in motion with body fully extended.

ejected several of slime, is in the act of turning away der to retreat and the nearest cover.

(All the photographs on these pages are by Roderick A. Holliday, F.R.P.S.)





4. A female *Peripatopsis* in the act of giving birth to young, which are produced singly or, more frequently, in pairs.

5. Young *Peripatopsis*, less than twelve hours old, with its mother. In general the young show no tendency to remain with their own parents although the creatures as a whole are gregarious.

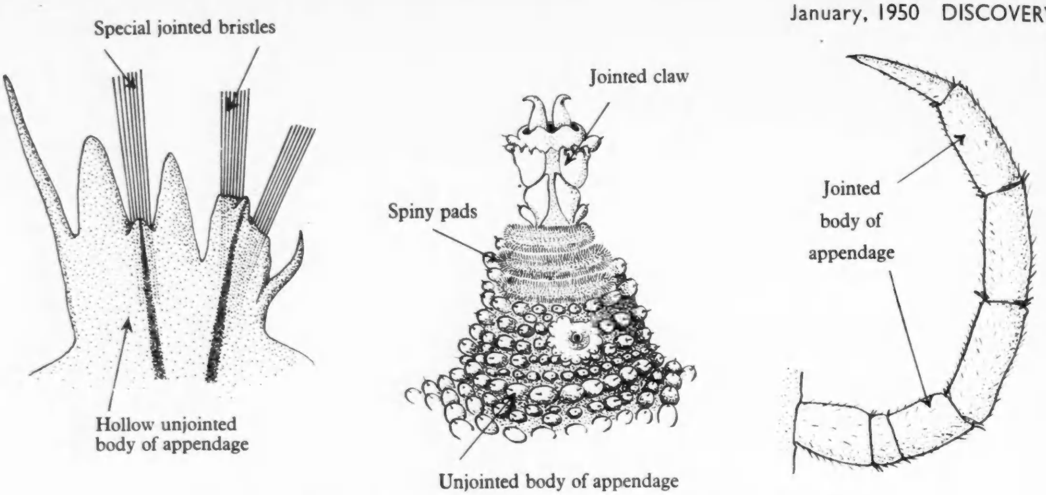


FIG. 2.—Trunk appendages of *Nereis* (*left*), *Peripatus* (*centre*) and *Lithobius* (*right*). Superficially they bear little resemblance to one another; yet the unjointed limb of *Peripatus* with its jointed claw is in many ways closer to the unjointed parapodium of *Nereis* with its jointed chaetae than to the fully jointed limb of the centipede.

Onychophora. The tendency of Arthropods to solve the problem of atmospheric respiration by this means is well known. The later and independent colonisations of the land by spiders and woodlice were also facilitated by the development of tracheae.

These ancestral Onychophora increased in numbers and spread slowly over a large part of the land surface of the world. Some of them became adapted at an early date to rather restricted habitats, in consequence of which their bodily organisation underwent little change. Others evolved newer, more efficient, and more versatile types of organisation. They improved their nervous systems and sense organs; they increased the number of segments in the head; they developed jointed appendages and modified them to perform a variety of tasks; they elaborated their thin cuticle into a hard outer shell whose plates were jointed between segments, the openings of the tracheal system necessarily becoming confined to the region of the joints. One group hit upon a particularly efficient plan and from it arose that vast but closely knit collection of animals, the Insects.

The rest suffered severely from the impact of the Insects. The majority of those that survived it now constitute that small and distinctly untidy group, the Myriapods. But the heaviest blows fell upon those forms which had retained all or most of the primitive features of the original stock. Of these—and that by something of a miracle—only the modern Onychophora have lived to tell the tale.

If this account is substantially true it follows that the Onychophora must have maintained their identity as a group for something over three hundred million years. In the virtual absence of fossil forms, this might be difficult to believe were it not that palaeontology provides us with several parallel instances. *Limulus* (the King Crab), which is an Arachnid, is known for about a hundred and fifty million years; a fish of the Order Crossopterygii, thought to have become extinct two hundred and fifty million years ago, was caught alive a few years back. Most astonishing of all, the Brachiopod genus *Lingula* (the Lamp-shell) has persisted unchanged for five hundred million years. Against this incredible record for a single genus, the survival of the Onychophora seems almost commonplace.

Australian Medicinal Plants

THE characteristic essential oils of native plants like the Eucalyptus were early noticed by settlers in Australia. The first distillation of an Australian essential oil was performed in 1788 by Dr. John White, Surgeon-General to the first Settlement.

He obtained an oil from the leaves of *Eucalyptus piperita* which "was found by Mr. White to be much more efficacious in removing all cholicky complaints than that of the English Peppermint". But it was not until 1854 that the first factory for extracting eucalyptus oil was started in Victoria.

Another pioneer who investigated the medicinal properties of Australian plants was Dr. Joseph Bancroft. In 1872 he reported his work on the leaves (called 'pituri') of a remarkable plant containing a stimulating principle. He wrote: "The old men before any serious undertaking chew these dried leaves appearing to use about a tablespoonful. A few twigs are burnt, and the ashes mixed therewith. After a slight mastication the bolus is placed behind the ear—to be again chewed from time to time; the whole of the bolus is at last swallowed. The native after this, is in a sufficiently courageous state of mind to fight, or undertake any serious business." These leaves came from the species of plant called *Duboisia hopwoodii*, and the main alkaloids present have been identified as nicotine and nor-nicotine.

These facts are recalled by L. J. Webb in his *Guide to the Medicinal and Poisonous Plants of Queensland*, just published by the Australian Council for Scientific and Industrial Research.

Birds *versus* Aircraft

FRANK W. LANE

IN 1910 a pilot took off in his aircraft from Long Beach, California. During his short flight a seagull hit the aeroplane and became wedged between the fin and rudder, which became immovable. Unable to control the aircraft, the pilot crashed and was killed.

As far as I can find out that was the first flying accident caused by a bird. And since that time birds have never ceased to be a menace to pilots and their machines. The maximum number of casualties from this cause came during the last war. The 'hedge-hopping' raids over occupied Europe brought a sharp increase in the bird-aeroplane collisions. During the Eindhoven raid in December, 1942 the chief danger appeared to come from the birds. One pilot said afterwards: "By far the biggest danger was from the birds. We ran into flocks of lapwings, swallows, geese, and even herons. One of the fellows came back with a goose foot still on the trailing edge; another shocked his ground crew by climbing out of the cockpit covered with blood. It was from a slaughtered seagull."

Aircraft-carriers and their seaplanes have also suffered from birds. Various sea birds perch on these ready-made islands and sometimes they peck at the fabric on the wings of the waiting aircraft. Holes are thus made and the airworthiness of the machines may be affected.

Between 1942 and 1946, 473 collisions between birds and aeroplanes were reported in the U.S.A. alone. *Time*, in its issue for November 6, 1944, reported: "The bird-bumping problem is becoming so troublesome that airlines rate the Civil Aeronautics Administration's wind-shield-strengthening experiments as the most urgent present research project."

In the recently published Ministry of Civil Aviation's Report, *Experiments in Clearing Birds from Airfields* (1949), information is given on the present position of the problem in this country. The Report, which is written by F. R. Adams and R. S. R. Fitter, says that 30 collisions occurred between R.A.F. aircraft and birds between September, 1946 and April, 1948. The aircraft involved ranged in size from Lancaster to Martinet. In eight of these collisions the aircraft was so badly damaged that it had to be withdrawn from unit strength for repairs. Sometimes so many birds have invaded airfields that they have had to be closed for a short time.

Although the great majority of bird-aeroplane collisions have not resulted in loss of life, it would be a mistake to underestimate the seriousness of the danger. The Report mentions an accident which occurred in the U.S.A. in January of last year. A Fairchild 'Packet' collided in taking-off with a flock of over a thousand small birds. The birds jammed the air intakes, thus causing the engines to become overheated. The aeroplane crashed and three of the crew were killed.

FIG. 1.—Peregrine falcons have been used to clear small birds from airfields.
(Photo by H. M. Webster.)

In the chapter on this subject in my book *Animal Wonderland* I mention several other fatal accidents to aeroplanes caused by birds. And I believe that a number—possibly a high proportion—of unsolved air disasters have been caused in this way. A swan or goose or large duck colliding directly with the wind-shield of a fast travelling aeroplane could easily cause the pilot to lose consciousness, if only temporarily, and before he could recover, or send out an S.O.S., the aeroplane might crash.

Enough has been said to show the reality of the bird menace. The problem is how to cope with it. Already measures have been taken to ensure, as far as possible, that wind-shields of aeroplanes shall be strong enough to stand up to normal bird collisions. Various experiments, both in this country and in the U.S.A., have proved that the conventional quarter-inch safety glass wind-shield collapses under the impact of a bird weighing three or four pounds at a velocity of 80 miles an hour, which is less than the normal landing speed of modern commercial aircraft.

After a number of tests with various types of experimental wind-shields, it has been found that one made of laminated glass-vinyl, with extended plastic edges and other strengthening devices, having a total thickness of about three-quarters of an inch, will resist the impact of four-pound bird carcases when projected experimentally at 300 miles an hour, and a fifteen-pound carcase at 200 miles an hour. Incidentally, the British Air Registration Board, the controlling body for civil aircraft, specifies that wind-shields should be of sufficient strength to withstand the impact of a four-pound bird "when the aeroplane is flying at the speed appropriate to climb immediately after take-off".

Other devices to protect aircraft from the worst effects of collision have been considered, and some tried experimentally. Among these are the installation of two separate panes of glass, one behind the other; the use of smaller panes in the wind-shield with more strength per unit; installing a metal grating which can be dropped over the wind-shield; and the use of a protecting shield for the pilot which will cut up birds before they crash into him.

But it is better to prevent a collision than to be prepared for it if it comes. It is with this aspect of the problem that the present Report, as its title suggests, is concerned: how to deal with the birds which congregate on or near the airfields. The Report says:

> The birds constituting the greatest danger to aircraft are gulls and members of the crow and plover families,

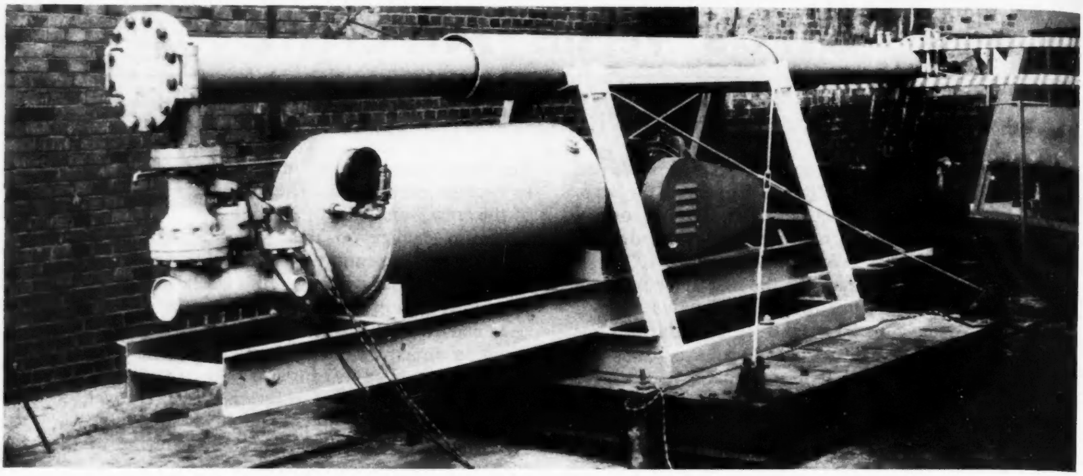


FIG. 2.—A compressed-air catapult which can project bird carcases at high speeds to test the resistance of wind-shields.
(Photo by Westinghouse Electric & Manufacturing Co.)

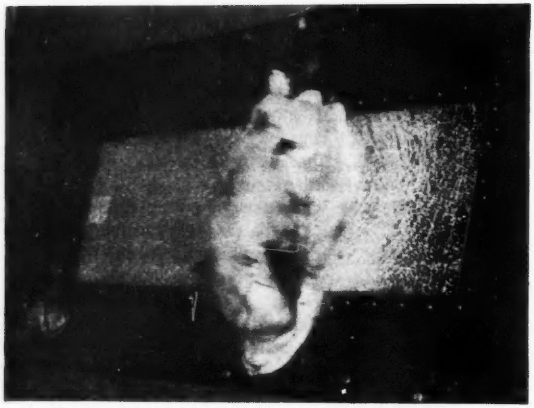


FIG. 3.—This high-speed photograph shows the impact of a 15-lb. bird carcase projected by the catapult at about 150 m.p.h.

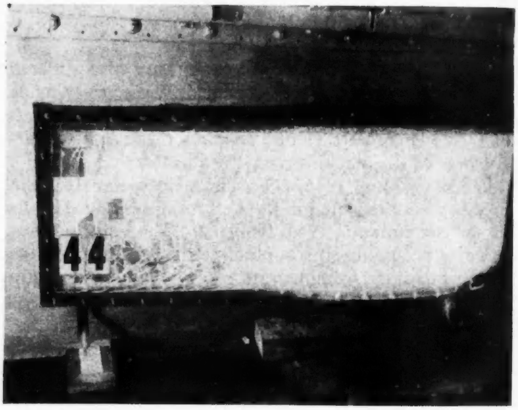


FIG. 4.—The result of a similar impact with a carcase weighing 13 lb.

FIG. 5.—To simulate a collision in the air this British rocket-propelled test trolley can be projected at a bird carcase at a speed of about 230 m.p.h.
(R.A.E. photograph. Crown copyright reserved.)

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which resort to the runways to digest and preen after feeding on the animal and insect life present in the soil. These birds disregard all aircraft on the ground and in the air, but will fly up and circle about in the path of any aircraft that is taking off or about to land, providing an additional hazard at a time when the pilot needs all his concentration. Other smaller birds, mainly skylarks, are present in fairly large numbers at airfields throughout the year, but the degree of danger is considered by Fitter to be less than in the case of the species mentioned (above).

Various attempts have already been made throughout the world to drive flocks of birds from airfields. Shooting (sometimes in defiance of protective laws!) and the use of Verey cartridges and rockets only scare the birds away for a short time. Similarly scarecrows, dogs and motor traffic have no permanent effect in frightening birds away.

In view of the failure of these and similar measures to achieve permanent results, it was realised that the whole problem would have to be thoroughly investigated anew. A meeting was therefore called in 1946 at which representatives of the Ministry of Supply, the Air Ministry, the Natural History Museum, and others interested in ornithology were present. It was decided that information should be obtained about the numbers and habits of the birds involved in the problem, and also that investigations should be made about using falcons to drive the birds away from airfields.

R. S. R. Fitter undertook the task of recruiting and organising throughout the country volunteer observers who were experienced bird watchers. They agreed to pay regular and frequent visits to airfields and to keep a record of relevant observations. Without this willing and voluntary labour the present Report could not have been compiled. The result of the observations showed, as mentioned above, that gulls and members of the crow and plover families were the worst bird pests on the airfields.

As earthworms form a large proportion of the diet of rooks, starlings, plovers and gulls it was suggested that efforts should be made to control the earthworm population on the airfields. If the birds' main source of food were removed the odds are that they would go elsewhere. But, the Report says: "Any method of removing the insect and animal life from the soil, a herculean task for the area of a modern airport, may well render the ground infertile and sour, and possibly create seasonal problems of dust."

Another expedient which was suggested was to let the grass grow long and thus make it difficult for the birds to reach the soil where their food lay. The objections to this idea are (1) that other unwelcome creatures might be thus encouraged to make their homes on the airfields and (2) it would remove the emergency landing area at present provided by a closely cut grass surface.

Several suggestions have been made to discourage birds from sitting or standing on the runways. A system of electric shock points would probably keep the birds away, but the idea has serious objections from other points of view. Gravelled runways, which apparently do not appeal to birds as resting-places, are objectionable from an operational viewpoint.

One of the most interesting measures suggested is the use of supersonic projectors giving a powerful high-frequency sound with a quavering effect. Such sounds have effectively disturbed all bird life within a radius of a quarter of a mile. As birds can hear sounds with a frequency of 20,000 to 30,000 cycles per second beyond the range of human hearing such supersonic 'scarecrows' can be used without disturbing the human inhabitants of airfields. Fitter, however, comments on this suggestion: "Apart from the unfortunate effect on local dog populations, this method would not appear to be suitable on terrestrial airfields. It might be tried at seaplane bases which experience trouble from birds." But at the time the Report was published, investigations on the use of supersonic bird-scarers were still being carried out.

The method of clearing birds from airfields which, up to the time the Report was published, has proved the most successful is the use of trained peregrine falcons. Mr. R. Stevens, who during the war was employed by the Services to help intercept pigeons used by enemy agents, undertook to obtain and train falcons for use on airfields.

It was intended to use the falcons first at the Coningsby airfield, which had been considerably troubled by birds, but an unexpected hitch arose. The local innkeeper was a keen and influential pigeon fancier, and he threatened to shoot "every so-and-so falcon that came within range!" The same understandable hostility to falcons on the part of pigeon fanciers was also encountered in other areas. No bird flesh appeals so strongly to a falcon as a pigeon's.

Eventually Shawbury was chosen; an airfield which was plagued with large numbers of plover. The result of the trials were satisfactory. It was found that a few short flights each day were sufficient to keep all plover away from the airfield. The mere presence of the falcon was sufficient to achieve this result—it was not necessary for a kill to be made. But once the falcons were removed there was no guarantee that the plover would not return within twenty-four hours.

The trial flights against sea-birds at Llanbedr were not so successful. Although the flight of the falcon scared off the gulls, they returned as soon as the falcon landed.

The results of the falcon trials persuaded the authorities to continue the work. A small number of airmen were trained as falconers, and additional falcons were obtained. Ten airfields were visited by the falcons and, on the whole, good results were obtained. But it was found that to be really effective the falcons had to remain at an airfield. Once the falcon detachment left the birds soon came back again.

It is obvious that to be really effective in clearing airfields and in keeping them cleared, a falcon detachment would have to be stationed at each airfield permanently. The Report considers such a wholesale method is not feasible either from an economic or staffing point of view. Some other method, possibly along the lines of a supersonic 'scarecrow', appears necessary if birds are to be effectively cleared from airfields at reasonable cost.

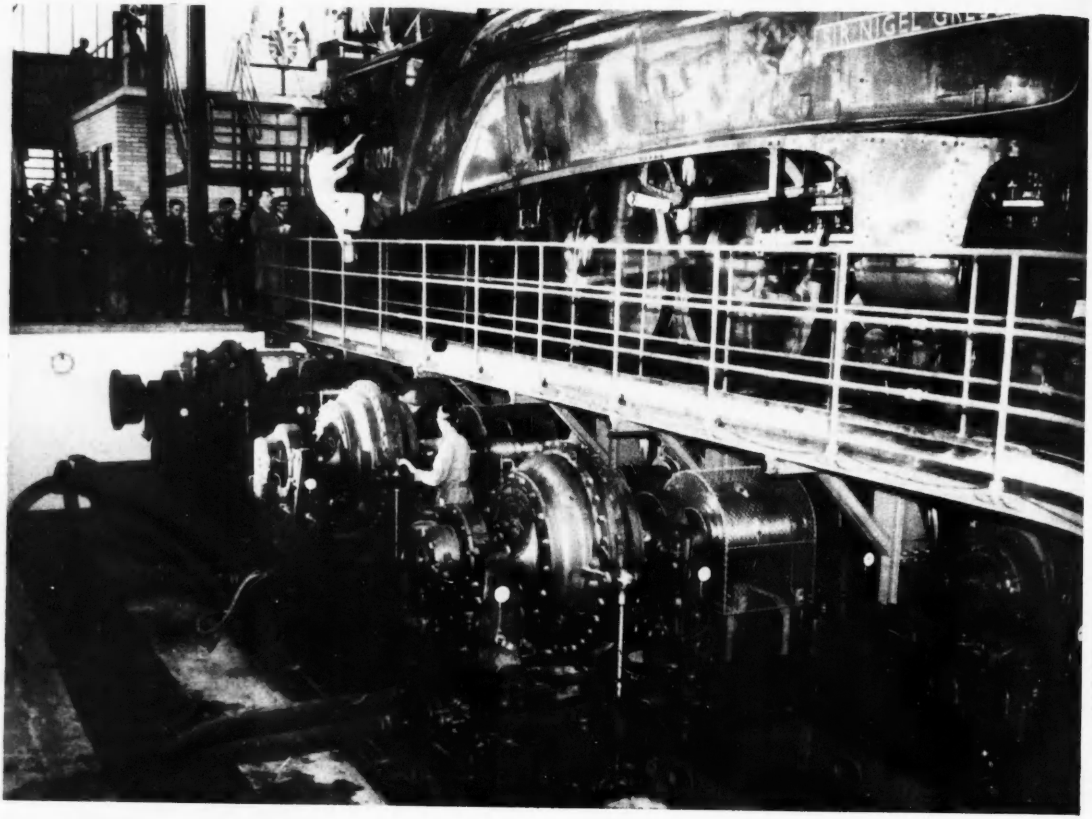

FIG. 1.—General view of the testing plant with one engine on the rollers actually undergoing a test. Three of the seven dynamometers are seen on the left.

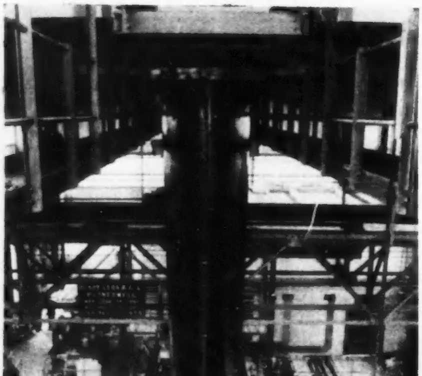

FIG. 3.—The test plant viewed from the roof showing the smoke evacuating chimney which can move along the test house to suit the length of engine under test.

(*Photo: by permission of British Railways.*)

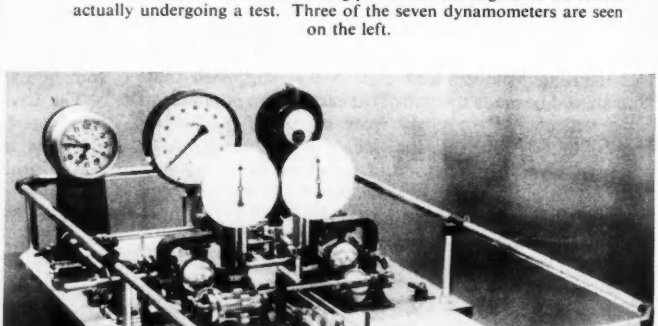

FIG. 2.—The recording table in the control room where the drawbar pull and other measurements are automatically recorded.

(*Photo: by permission of British Railways.*)

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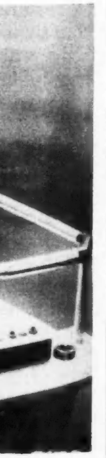

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Testing Locomotives at Rugby

W. O. SKEAT, B.Sc. (Eng.), A.M.I.Mech. E., M.I. Locomotive E.

THE recent opening of the locomotive-testing station at Rugby marks the beginning of a new era in British locomotive design since it is now possible for the first time in this country to carry out a complete series of tests on the performance of a modern high-powered locomotive on up-to-date apparatus, under steady controlled conditions. Such conditions of operation are practically impossible to obtain during ordinary running, owing to the continual changes in gradient, curvature of track, wind resistance, and weather which are inevitably encountered during an ordinary run.

In the past, we have had to 'make do' in Great Britain with dynamometer car tests, in which a specially equipped carriage is placed at the head of the train, next to the engine to be tested. The 'heart' of this vehicle is the great spring which is linked to the coupling between the locomotive and the train, and which deflects according to the magnitude of the pull in this coupling. Delicate recording apparatus connected to this spring enables a continuous graph of its movements to be made, whilst the speed is recorded by a steel wheel which is rolled along the top of the rail, the revolutions of the wheel being also recorded on an instrument within the vehicle.

By testing a number of locomotives in this way, or by recording the performances of a given locomotive on a number of runs, results are obtained which, though comparable among themselves, are not entirely suitable for application to design problems, owing to the inevitable variations in the working conditions. The results are, in fact, averages of the various conditions of working, and would be almost impossible to apply to any locomotive design which might be contemplated in the future.

There is another possible method of measuring locomotive power output on actual runs, and this involves the use of special 'brake locomotives' in the train. The tests are carried out at constant speed, and under a boiler pressure which is kept as nearly constant as possible. No changes in the setting of the valve gear (which distributes the steam to the cylinders) or in the opening of the regulator (the main steam valve) can be permitted in such tests. In other words, it is like driving a motor vehicle without changing gear or altering the throttle. The brake locomotives are real locomotives, but without any water or fire in them; they are towed with their valve gear set for the direction contrary to that in which they are being hauled; they therefore act as power absorbers, and in the latest example of this method of testing in Great Britain, they are automatically controlled, the power output of the locomotive under test being absorbed by electric generators. This kind of test enables a very close control of speed to be achieved.

It is, however, undeniable that for many reasons it is a great advantage to keep the locomotive stationary while it is under test, so that the various items which are being recorded are under close inspection. For this purpose a stationary plant is essential. The pioneer installation of this kind in Great Britain is that built by the former Great Western Railway at Swindon, which has given some most valuable results in service. The locomotive to be tested is mounted on rollers, the spacing of which can be adjusted to suit the axle spacings of the locomotive; its drawbar (the coupling by which the engine is linked to the tender and its train) is attached to a spring, as on a dynamometer car or to a hydraulic cylinder, and the various recording instruments are brought into use.

In a plant of this kind there must, of course, be adequate means of absorbing the power generated by the locomotive. In the pioneer Swindon plant, the rollers caused a large wheel to rotate, which was coupled to an electric generating plant. In the new Rugby installation, the rollers are coupled to Froude hydraulic brakes or dynamometers, one of the characteristics of which is that for any given setting of the locomotive controls, the locomotive-cum-brake assembly is inherently stable, and any small variation in power output will only produce a very small speed variation. In the Froude dynamometer, the only increase or decrease in torque is a function of the speed; it is thus a virtually self-governing device, and its characteristics help considerably in keeping the speed steady, despite any alterations which may be made in the controls.

Each Froude dynamometer can absorb up to 1200 h.p. in the Rugby plant, and the total rated capacity of the plant is 4500 h.p.: this figure can, however, be increased to 6000 h.p. if necessary. The maximum equivalent speed which can be dealt with is 130 m.p.h. With an eye to possible future increases in the maximum permissible axle loading (at present $22\frac{1}{2}$ tons in Great Britain), the rollers have been designed to carry a maximum axle load of no less than 30 tons.

The power which the dynamometers absorb must be dissipated, and for this purpose the power absorbed is converted into heat which is carried away by circulating water. With a high power output, the consumption of water would be very considerable, so it has been thought worth while to install a cooler for the circulating water system. When dissipating 4500 h.p. the respective inlet and outlet temperatures of the cooler are 140°F. and 100°F. respectively, the greatest water flow being about 30,000 gallons an hour.

In the Rugby plant, the tractive effort at each axle can be measured by an ingenious device. Each dynamometer is furnished with an arm by which the torque load is transmitted to a spring. When the dynamometer is under load, the deflection of the spring is transmitted by electrical means to instruments in the control room of the test plant, the graduations of the instruments enabling the torque to be read off as tractive effort at each driving wheel. A master control device enables all the dynamometers to be operated together; alternatively, each one can be controlled separately.

The power output of the locomotive is recorded by means of an Amsler dynamometer attached to the drawbar. The actual pull transmitted by the drawbar is taken up by a hydraulic cylinder, the pressure in which thus varies directly with the drawbar pull and is therefore easily transferred to a small auxiliary hydraulic cylinder and piston by which the actual recording pen is operated. This pen,

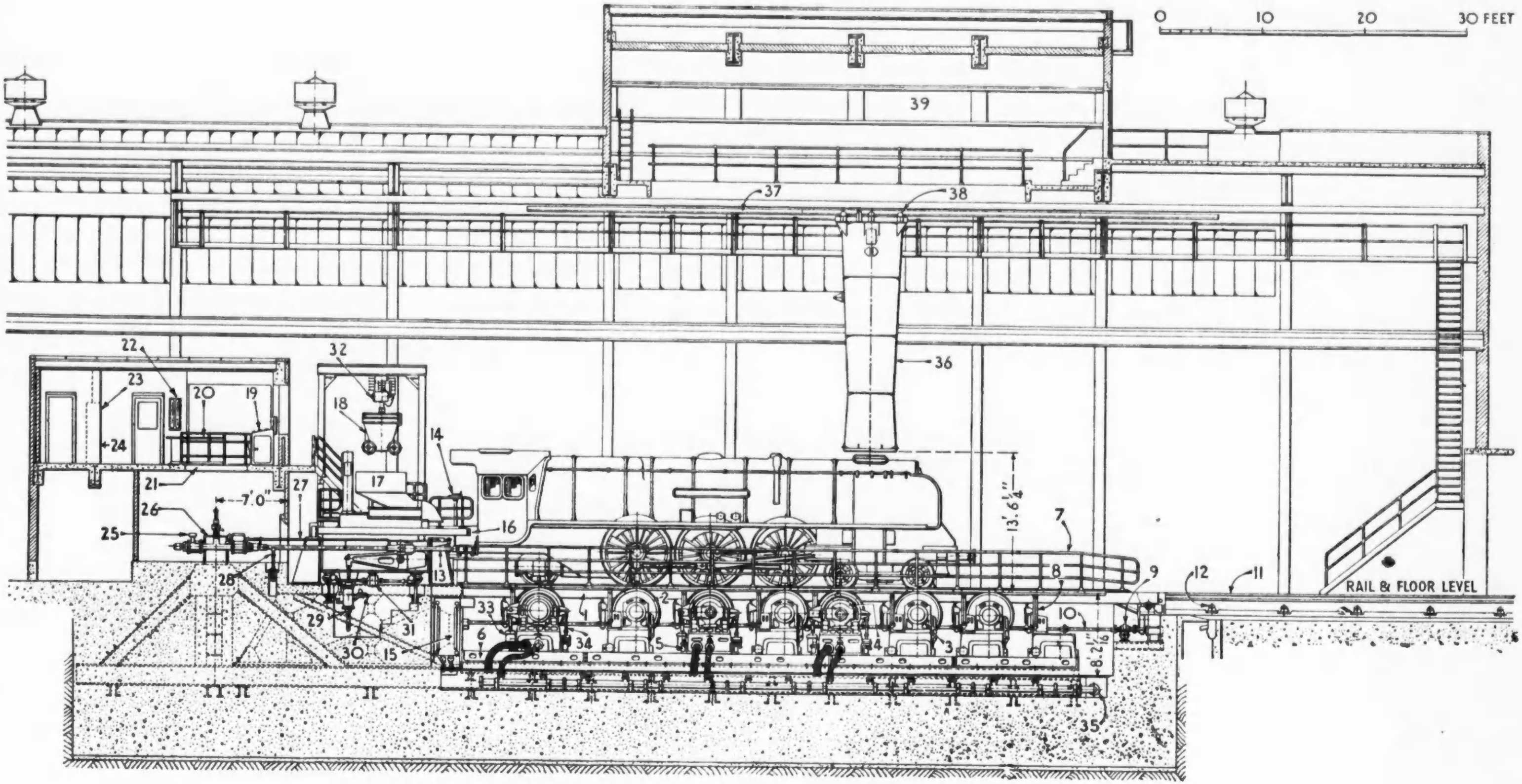

FIG. 2.—General arrangement of the locomotive testing plant. (*By Courtesy of Railway Gazette.*)

1. Locomotive lifting platform
2. Main drum
3. Drumshaft bearing
4. Dynamometer
5. Dynamometer roller
6. Dynamometer soleplate
7. Removable gangway
8. Crossbeam—gangway support
9. Reduction gear—lifting jacks
10. Operating shaft—lifting jacks
11. Extension rails
12. Rollers—to withdraw lifting platform
13. Main drawbar
14. Boiler feed control
15. Injector overflow measuring tank
16. Firing platform
17. Coal hopper on weighing machine
18. Portable coal truck
19. Dynamometer control desk
20. Amsler recording table
21. Glass panel in floor
22. Boiler feed tank tele-gauges
23. Gas analysis panel.
24. Pressure and temperature panel
25. Amsler dynamometer
26. Anchorage H beam
27. Mediating gear
28. Rear drawbar support
29. Damping dashpot
30. Dashpot motor operated needle valve
31. Dashpot carriage elevating gear
32. Electric travelling hoist
33. Dynamometer torque measuring gear
34. Dynamometer dashpot
35. Dynamometer water supply ring main
36. Chimney
37. Chimney sliding plate
38. Chimney rollers
39. Smoke corridor

which is linked to an accurately calibrated spring, is made to trace the variations in drawbar pull on a continuously moving roll of paper which is moved along beneath it, the paper being moved in direct relation to the peripheral speed of the locomotive's driving wheels.

Great care had to be taken, in the construction of the plant, to ensure a massive foundation for carrying the main hydraulic cylinder taking the drawbar pull. A steel post forms the main anchorage; it is supported by a robust steel framework embedded in concrete so as to form a solid block weighing some 3000 tons.

The control room contains all the recording instruments necessary for complete series of locomotive tests. The central feature is the Amsler recording table where the drawbar pull records are obtained by means of special integration devices, the power developed by the locomotive is recorded, as well as the work done and the speed. Other instruments enable boiler feed water, inlet and exhaust steam temperatures, smokebox, firebox, and ashpan vacua, and the composition of the flue gases in the smokebox to be recorded continuously. Extra pens are also available, so that any additional variable can be recorded by an observer stationed in the cab of the locomotive under test.

Naturally the whole plant had to be designed so as to be capable of a wide range of adjustments to suit a variety of locomotive types. Not only are the rollers and dynamometers movable so as to conform to the wheel spacings within a large range, but the firing platform (which is substituted for the tender) also can be adjusted in height to agree with the cab floor level of the locomotive. The height and overall length of the drawbar can also be varied, according to the disposition of the dragbox (i.e. the casting to which the drawbar is attached) of the particular design. Racks and pinions move the rollers and dynamometers to approximate positions, after which they are clamped down, and final adjustments are made by a special device which enables correct centring of the rollers below the driving wheels to be carried out to an accuracy of about 0·01 in.

The method of mounting the locomotive on the rollers is of great interest. Two massive steel girders running the whole length of the test bed are moved to positions just alongside the rollers. Support for these girders is afforded by jacks, one of which is located by each roller. This whole assembly thus forms a sort of table which is capable of being raised or lowered by the jacks through a small distance; when fully raised, the girders form tracks on to which the locomotive's weight is transferred through the flanges of its wheels. In that position, the 'treads' of the tyres (the tyre surface normally on running rails) are lifted clear so that the rollers are not in contact with them.

The need to keep the locomotive's driving wheels exactly in the same vertical centre lines as the rollers, during a test, is paramount. The record of drawbar pull is seriously affected by any deviation from the true vertical position, since a gravitational error is thereby induced. To overcome this difficulty a device known as the Amsler mediating gear is fitted, by means of which the deviation is nullified by pumping oil into or out of the main hydraulic cylinder to which the drawbar transmits its pull. In addition to making this correction, the mediating gear, by means of a special integrating gear, sums the 'errors' in drawbar pull throughout a test, so that a correction can be applied to the amount of work done by the locomotive, as given on the records. Another direction in which great care is necessary to ensure that test results are not prejudiced is the adjustment of the drawbar in its coupling to the Amsler hydraulic dynamometer. Since it is easily possible for resonance to build up in the elastic system comprising the locomotive itself and the drawbar, as a result of which a large amount of vibration can be produced, a damping device in the form of a substantial dashpot is included between the dynamometer and the drawbar itself. This successfully prevents the building up of dangerously large forces (which, it is estimated, might rise to plus or minus 100 tons) under the influence of synchronous vibration in the elastic system.

The new test plant has quite a long history. As already mentioned, the installation at the Swindon works of the Great Western Railway was the first example of its kind in the country and although it enabled valuable information to be derived from the tests carried out on it, there were certain limitations in the design which indicated that a larger and more completely equipped plant would be of great benefit to British locomotive engineers.

The main body of support for the project was enlisted by Sir Nigel Gresley, who held the position of Chief Mechanical Engineer of the London and North Eastern Railway on the formation of the company in 1923 until his death in 1941. Sir Nigel worked tirelessly for the establishment of the testing station and gave great prominence to it in a Presidential Address to the Institution of Locomotive Engineers in 1927. In the following year, the Department of Scientific and Industrial Research joined forces with the four main line railway companies and formed a committee to examine the project. The serious industrial slump which hit the railways shortly afterwards prevented any further action for some time and work was shelved until conditions improved.

In 1934 a new committee was formed to revive the idea. Eventually, in 1936, a definite proposal was made, by which the London Midland and Scottish Railway and the London and North Eastern Railway jointly undertook to build a testing station, which, though primarily for their own use, was to be made available to the other two companies when not required by themselves.

The next step forward was made in 1937, when a superintending committee was formed to make ready the final designs and later to build, equip, and manage the test plant. The superintending committee consisted of the Chief Mechanical Engineers of the two participating railways, Sir Nigel Gresley and Sir William Stanier; and a Superintending Engineer, Mr. R. C. Bond (who is now Chief Officer for Locomotive Construction and Maintenance to the Railway Executive), was also appointed. Under this executive authority, a site for the plant was chosen at Rugby, as a convenient location for both railways, and the design of the station then proceeded rapidly. Excellent progress was made until the outbreak of war in 1939 again caused the project to be shelved. The unfinished building was made weatherproof, and no further constructional work was done till 1944, when a fresh start was made.

Mr. D. R. Carling, as Superintending Engineer, carried the scheme through to completion. On October 19, 1948, the testing station was officially opened by the Minister of Transport.

Far and Near

Harwell's Cyclotron

THE synchro-cyclotron at the Atomic Energy Research Establishment at Harwell was given its first full trial last month (December), and its performance was well up to expectations.

This machine, the largest in Europe, can make atomic particles travel at 95,000 miles a second. It is installed in an underground room 100 ft. long, 45 ft. wide, and 12 ft. high. It has a 6-ft. reinforced concrete roof. The Ministry of Supply states that the result had been achieved much sooner than might have been expected. Constructional work of the complex buildings and equipment had taken just under three years, but the experimental work of final tests and adjustments took only a few weeks.

The machine is at present producing a total accelerating voltage of about 160 m. volts. When final adjustments have been carried out this will be increased to 180 m. volts or more. The particles now being accelerated are the atomic nuclei of hydrogen which are heavier than electrons and also much more powerful in producing nuclei disintegrations.

The magnet of the cyclotron contains 700 tons of steel. Its oil-cooled energising winding contains 80 tons of copper and consumes over 300 kilowatts of electrical power. Its circular poles are 110 in. in diameter and are 12 in. apart. The oscillator can give a maximum power of 150 kilowatts. Large vacuum pumps operate day and night to maintain a high vacuum in the accelerating system which has a volume of about 500 cu. ft. The main parts of the cyclotron are cooled by circulating purified water.

New Atomic Energy Establishment: Building Work to Begin This Year

THE Ministry of Supply announces that a site has been selected at Capenhurst, near Chester for the construction of an establishment connected with the Ministry's atomic energy programme.

It will be necessary to acquire some 150 acres of adjoining land. The need to take agricultural land for this purpose is regretted, but a number of rigid requirements had to be satisfied in the selection of a site. It was only after a very wide search that the choice of Capenhurst was confirmed.

Survey work has begun, and construction work, which at its peak will employ several thousand men, will begin this year. The establishment will ultimately employ an operating force of a similar size.

Much of its labour will be drawn from the Merseyside Development Area, where it will reduce unemployment, a factor in the selection of the site to which the Government attach importance.

No harmful effects to the neighbourhood can arise from the work to be carried on at this establishment.

Aircraft in the Science Museum

THE handbook to the Aeronautical exhibits in the Science Museum has now been revised. Part II (Catalogue of Exhibits with Descriptive Notes) is now published, and is available from the Stationery Office, price 3*s*. Part I (Historical Survey) is due for almost immediate publication.

London–Birmingham Television Link

THE Midland Television Service came into operation on December 17. The technical innovations involved in the extension of B.B.C. television are interesting, particularly those connected with the radio link which relays television signals from Alexandra Palace to the new television station at Sutton Coldfield.

Apart from putting this country right in the fore-front of television development, since nowhere else in the world does there exist a beamed relay system so technically advanced for continuous service, the link will be watched with great interest far beyond the confines of these islands because of its potential value in telecommunication projects generally.

The contract placed by the G.P.O., with the General Electric Company, on specifications drawn up by the Radio Branch of the Engineer-in-Chief's office, stipulated that the relay system must be capable of extension up to 400 miles. The radio link also has to pass a signal band-width of three megacycles a second, or the equivalent band-width occupied by 600 simultaneous telephone conversations. It is suitable for relaying the 405 line, 50 frames a second, television signals of the waveform transmitted at present by the B.B.C. from Alexandra Palace to the new television station at Sutton Coldfield.

When completed the link will provide simultaneous two-way transmission of the vision signal (sound will be carried by the existing G.P.O. coaxial line) between the two cities. At the present stage a reversible link only is ready so that transmission in either direction can be obtained according to the B.B.C.'s programme requirements; but the full installation will be in operation by June 1950. The existing reversible system, comprising six stations each situated not more than 20 miles apart, uses two transmission frequencies: 870 and 890 megacycles. A station which receives on one transmits on the other, and *vice versa*. These two frequencies are used for either direction of transmission with the reversible link; they will eventually be used for one direction of the two-way link, 917 and 937 megacycles being used in similar fashion for the other direction.

The use of these ultra-high-frequencies necessitates optical paths between transmitters and receivers for satisfactory and consistent performance, and the sites for the stations were naturally on the high ground between London and Birmingham. The television signal is transmitted over the radio link by frequency-modulation of the 900 megacycle carrier.

The power transmitted from each relay station is of the order of ten watts; the received power is about a microwatt—thus the gain of a repeater station is 70 decibels or ten million to one in power.

An important feature of the television radio link is that it is entirely automatic in operation. All the repeater stations are capable of working almost indefinitely without attention. Should a fault develop, duplicate equipment automatically comes into service; the control engineers in London and Birmingham are informed by means of signal lights that a fault has occurred and that standby apparatus is in operation. If this supervisory system fails the stations will continue to work on pre-set time switching.

Considerable war-time experience in the field of radar has allowed the designers and manufacturers to produce this unique system of beamed radio communication in just over two years, and their considerable achievement will be appreciated wherever the problems involved in such a project are understood.

Radar Memorial

A TABLET recording the occupation of King School, Whitby, Surrey, by the Navy's Radar Department from 1942 to 1948 was unveiled at the School on November 11. At the ceremony, Mr. C. E. Horton, Chief Scientist to the Admiralty Signal and Radar Establishment, told how the bombing of Portsmouth made evacuation necessary. The department moved to the school and became a hive of scientific activity. Many momentous decisions were made there.

Science and the 1951 Exhibition

SCIENCE will be well to the fore in the 1951 Exhibition. The South Bank exhibition near Waterloo Station, for example, is planned to show how much of the past and the future of Britain is founded on the achievements of her scientists, technologists, industrialists and designers. The site is to be divided into two sections, one showing the land of Britain and what the British have derived from it, and the other showing the people themselves in their domestic surroundings.

Most outstanding of the South Bank buildings will be the Dome of Discovery, in which will be emphasised the British pre-eminence in discovery and exploration not only by land and sea but in the nature of the living world and the universe. Thus, ranged alongside the achievements of such men as Cook and Livingstone, will be displayed the discoveries of British scientists such as Newton, Darwin, Faraday, Thomson and Rutherford, without which so much that is illustrated elsewhere in the Exhibition would not have been possible. One section will illustrate the latest knowledge of the structure and nature of matter, culminating in a display of nuclear energy. Other sections will be

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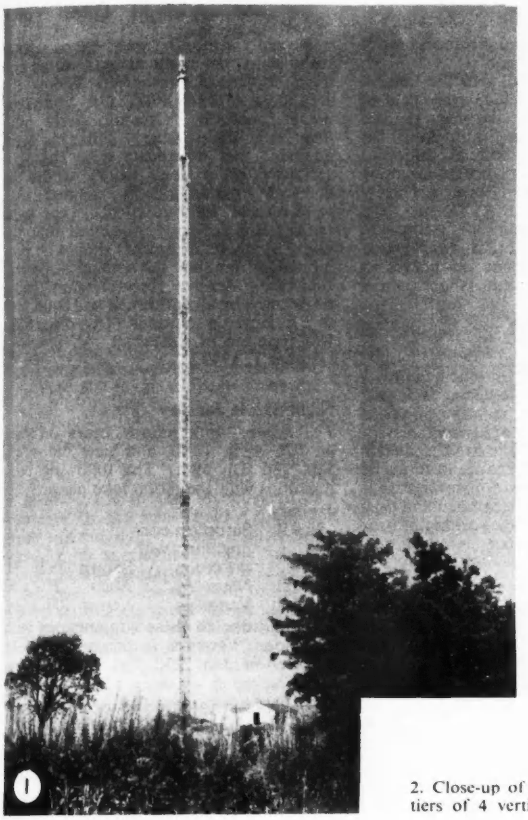
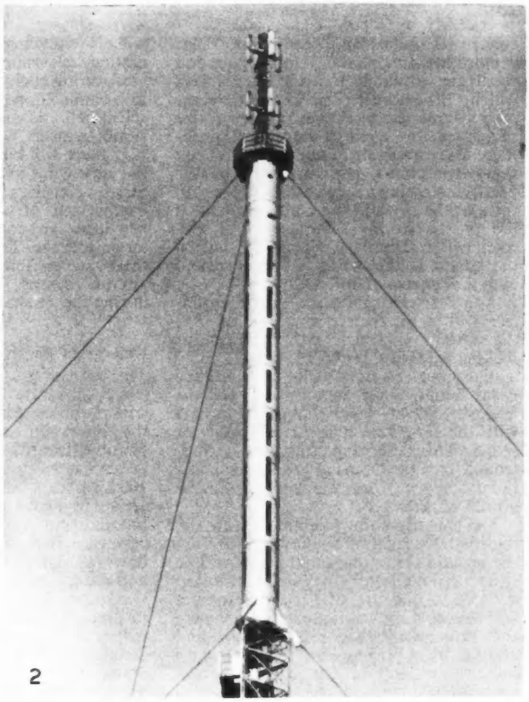
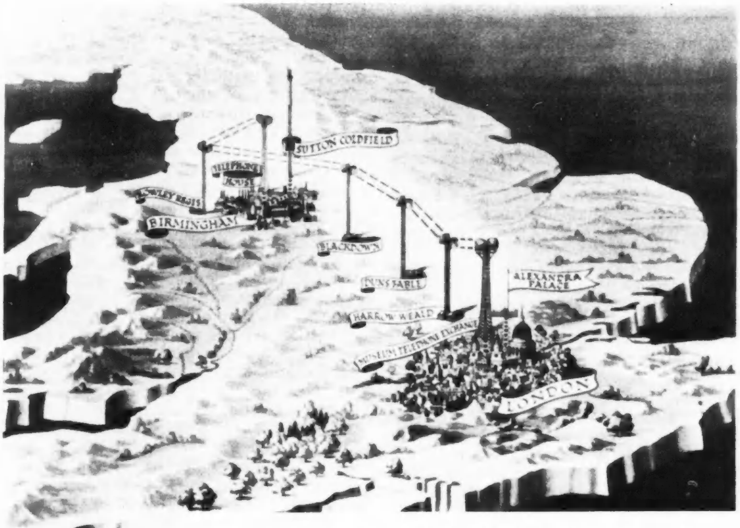




1. The 750-foot aerial mast at Sutton Coldfield.

(Photo by British Insulated Callender's Construction Co.)

2. Close-up of aerial, which transmits both sound and vision signals; there are two tiers of 4 vertical dipoles arranged in a cross. The cylindrical structure below is for VHF experiments.



3, 4. The London–Birmingham Television Link. The photo shows the terminal aerial in London, mounted on top of the Museum telephone exchange.

(G.E.C. pictures.)

concerned with land, sea and Polar exploration, Inner Space, Outer Space and the living world. Included in the displays will be British enterprise in the development of overseas territories, by new forms of survey, by research into local problems, by combating disease and difficult living conditions, and, in short, by the yearly increasing knowledge of the earth, the sea, the sky and the plant and animal life of the world. Constructed of aluminium the Dome of Discovery will be the largest in the world—97 ft. high and with a diameter of 365 ft.

Another striking feature in the exhibition will be the shot tower. Built in 1840 the tower was used until recently for making lead shot, but in 1951 it will carry a lighthouse lantern and bowl-shaped radar aerial, 30 ft. in diameter, for the 'radio telescope' which will make contact with the sun, stars and meteors in outer space. This radar apparatus will be controlled from the Dome of Discovery where radar echoes from the moon will be visible on a screen.

The part played by scientific research in improving agricultural methods and in the breeding of animals and plants will be shown in the 'Country' pavilion. A section devoted to the use of natural resources will lead to an industrial exhibition where the skill of British technologists and craftsmen in turning raw materials into finished products can be seen. In a 'Sea and Ships' pavilion the exhibits will include a ship-testing tank and will range from marine engines to small tackle. Working models of docks and airports and full-sized locomotives, road vehicles, aircraft and ship equipment will be housed in the 'Transport' section, which will also show telecommunications, broadcasting, television and cables.

Covering such a small area the Exhibition cannot hope to include every field of scientific and industrial progress but simultaneously with the South Bank display there will be a scientific exhibition in the new wing of the Science Museum at South Kensington and one of heavy engineering at Glasgow. To give the provinces an opportunity of seeing the scope of the London Exhibition, two travelling exhibitions, one on board an aircraft carrier, will tour the country during the summer.

Detergents and Sewage Disposal

The increasing use of synthetic detergents (soap substitutes) for domestic or industrial purposes seems to be interfering with the operation of sewage works, with possible hazards to public health. Detergents may be present in concentrations of 100–200 parts per million in sewage as it arrives at the works for treatment and they interfere with the smooth working of processes devised to produce harmless outflows (as regards possible pollution of land and water). Sewage is normally treated in two stages, first chemically (sedimentation) to precipitate out most of the suspended matter and then biologically by bacterial action to remove residual pollution materials. The effect of detergents is to 'hold' foreign matter in suspension and thus the sedimentation treatment is hardly effective at all or at best less effective than before. Much more suspended material is therefore carried over to the biological stage of treatment putting a tremendous strain on this section of the works.

Recently a meeting was held of sewage technicians, detergent manufacturers and local industrialists in the West Riding, the area most seriously affected, to discuss the whole question. Opinions were very divergent, the sewage technicians were adamant that detergents were having a serious effect in their works, whilst the detergent manufacturers claimed they were almost without effect. One local industrialist seriously suggested that the use of synthetic detergents should be prohibited by law but the general hope was that the intensive research now being prosecuted by all concerned will soon lead to a favourable solution. (This discussion was reported in *Chemistry and Industry*, October 1, 1949.)

Night Sky in January

The Moon.—Full moon occurs on Jan. 4d 07h 48m, U.T., and new moon on Jan. 18d 07h 59m. The following conjunctions with the moon take place:

January			
9d 05h	Saturn in conjunction with the moon	Saturn	0·2° N.
10d 10h	Mars ,,	Mars	2° N.
19d 14h	Venus ,,	Venus	10° N.

In addition to these conjunctions with the moon, Venus is in conjunction with Jupiter on Jan. 25d 13h, Venus being 7·3° N.

The Planets.—Mercury sets an hour after the sun on Jan. 1, but during the month draws closer to the sun and is not favourably placed for observation. Venus is still conspicuous in the western sky, setting about 3 hours after the sun early in the month. The planet moves closer to the line from the earth to the sun, attaining this position on Jan. 31, on which date less than 1 per cent of the illuminated disc is visible—in other words, viewed through a telescope towards the end of the month, Venus presents the appearance of a thin crescent. Mars rises at 23h 25m on Jan. 1 and at 22h 10m on Jan. 31, and can be seen near Eta Virginis in the early part of the month and just east of Gamma Virginis at the end of the month. Jupiter sets a little more than 2 hours after the sun on Jan. 1 and about an hour after the sun towards the middle of the month after which it is not well placed for observation. Saturn rises at 22h 10m and 20h 10m on Jan. 1 and 31 respectively, and can be seen throughout the morning hours until a little before sunrise, slightly east of Sigma Leonis. An interesting phenomenon occurs on Jan. 9; a conjunction of Saturn with the moon (already referred to) takes place at 5 a.m., but for some time before and after this those who are looking out can see the proximity of the two bodies. At 5 a.m. their apparent distance apart is about one-third of the moon's diameter.

The shortest day occurred on December 22. Notice a curious phenomenon at this time. The afternoons increase in length while the mornings decrease. The explanation is too involved to give here; but anyone who is interested will find a full explanation in Davidson's *Elements of Mathematical Astronomy* (p. 73), published by Hutchinson.

Letter to the Editor

Russia's Atomic Bomb

Sir,

The article "The Atom Devalued" (Discovery, November 1949), is in my opinion a specious attempt to justify the opinion that Russia's discovery of the method of making atom bombs does not alter the U.S.A.'s strategic preponderance.

The article seems to be based on a number of fallacies. Firstly, the Russians evidently have an enormous strategic advantage in that they know the location of all the key targets in the U.S.A., whereas the Russian targets are certainly not known. This demolishes the argument about the importance of the "strategically effective number of bombs".

Secondly, while it is true that Russia has no military bases on foreign soils, whereas the U.S.A. has at least 400, nevertheless the Russians are known to have numerous bases along the White Sea, and indeed flew the first (and as far as I know, the only) aeroplane across the North Pole. It follows that it is by no means certain that the Soviet Union could not deliver atom bombs to targets in the U.S.A.

Thirdly, it is fallacious to assume that the Russians will be able to increase their stock of atom bombs only at the same rate as the Americans. It seems far more reasonable to suppose that they will increase production of the bombs at a rate comparable with the far greater rate of development of their first bomb. The assumption that Russia's hypothetical resources of uranium are hardly likely to compare with those commanded by the U.S.A. is wholly gratuitous.

Fourthly, it is entirely untrue to state that Russia was unwilling to submit to *any* system of international inspection. It has been made clear again and again that the Russians would not submit to inspection by an American-dominated body while America still possessed a stock of bombs. This is quite a different thing altogether. Would we in this country have allowed a close inspection of our poison gas factories and stocks by a body dominated by the Germans (just before the recent war) while they had (hypothetically, of course) a vastly superior poison gas industry and stocks? Would we do so even if the Germans had promised to destroy their stocks at some future date (unspecified) to be decided on by the same German-dominated body?

Yours faithfully,

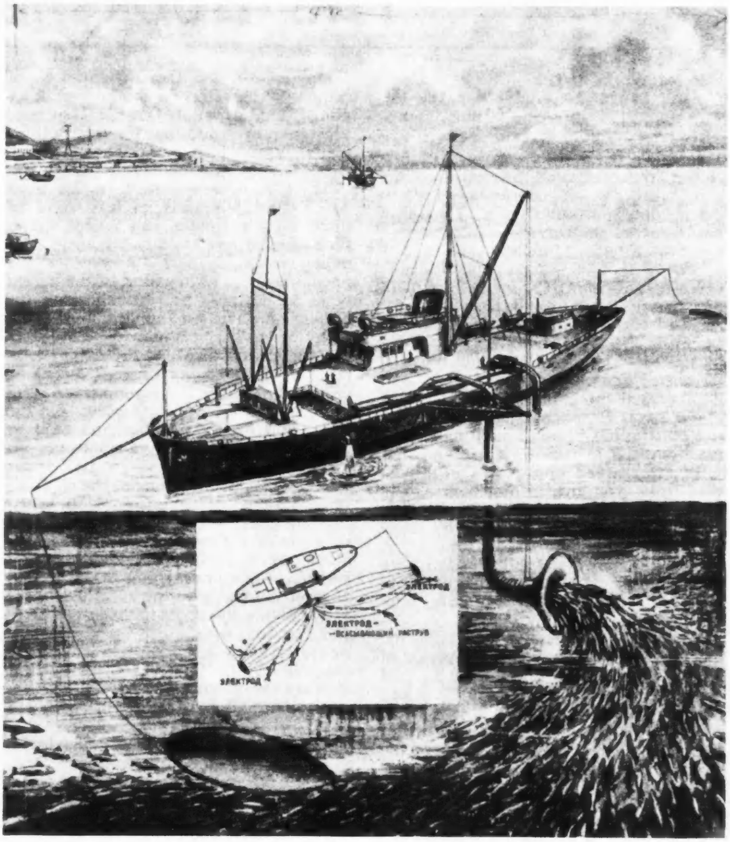
Bernard Loshak, East Bergholt, Colchester.

Catching Fish by Electricity

In the October 1949 issue of the Russian periodical *Tekhnika Molodezhi* an interesting account is given of a new technique designed for catching fish in the open sea. The technique was worked out by a Russian scientist, M. F. Chernigin, who had previously developed a method for the mechanised unloading of fish trawlers. Mechanical methods in general have failed because they cause damage to the fish. Just before the last war the German firm 'Borsik' tried to use the air-lift pump (which uses compressed air) for this purpose but the results were not very satisfactory. Accordingly, Chernigin developed the following system. A suction pipe, branching from the main pipe, is lowered into the hold of the trawler. The hold is flooded with water and a strong stream of water is propelled through the main pipe. The 'mixture' of fish and water is sucked in from the hold and carried through the main pipe to a separator where the water is diverted and the fish is delivered to a conveyer. In this way a hold is emptied in from 3 to 5 minutes instead of after hours of work by several men. The fish does not suffer any damage in the process.

Attempts were made to use this system for actually catching fish in the sea but it was found that the fish turned resolutely away as soon as they sensed the current taking them towards the suction pipe. It was therefore necessary to devise means for driving the fish towards the pipe. One of the possibilities involved the use of alternating currents, which are known to be avoided by fish; advantage had already been taken of this effect for keeping fish away from hydroelectric turbines. Chernigin found the method unsuccessful and proceeded to experiment with direct currents. He had a horn-shaped funnel fixed to the suction pipe and lowered from the ship into the water. This funnel piece served as one of the electrodes. Two more electrodes, one on each side of the first and of opposite polarity to it, were also lowered into the water. When the pump was started without any current passing through the electrodes it could be seen from the ship that the fish were actively moving away from the funnel. There was, however, a startling change as soon as the electrical current was switched on. The fish moved towards the funnel, and the result was a steady flow of fish through the pipe. In 11 hours over 25 cwt. of fish was caught in this way. The fish so caught were free from any damage.

The account states that more research is necessary on the method, which appears to hold great possibilities, however.



Artist's impression of the new Russian method of catching fish.

A Film about the Liver Fluke

The film "Liver Fluke in Great Britain" shows the damage done by liver fluke, its life history, the ways it is being investigated, and some methods which can be used to control the disease. It is an outstanding film, which will appeal to the general public as well as to the farmers for whom it is intended. Some of the cinemicrography of events which are rarely seen is of special interest to biologists—the emergence of a miracidium from the eggshell, or a cercaria throwing off its tail and encysting. Incidentally, sequences such as these (or better still, longer versions of them), made up into a silent film, would be invaluable teaching material.

The ease and speed with which knowledge can be assimilated from a film which is so imaginatively designed as this is very striking. For instance, the life history of the fluke is first told as it affects the farmer. It is then recapitulated historically. There is an amusing modification of the familiar diagram representing the life cycle; the conventional segmented circle is broken up, and each piece is illuminated as its fragment of knowledge is discovered, until at last the jigsaw puzzle fits together. In this ingenious manner the complexities of the life cycle are quickly and painlessly impressed on the mind, and at the same time one gets a vivid picture of the way isolated observations are pieced together, and the relatedness of apparently unrelated things is gradually revealed. The lucid and accurate exposition of biological facts about a parasite, its hosts, and their human importance is only a part of the contribution which the film makes to scientific culture. Another is the faithful picture it gives of the way research is carried on—not the happy chance experiment which hits the headlines, but the meticulous, everyday humdrum labour that gets the bulk of research done. Some of the many kinds of work now proceeding to devise suitable methods of combating fluke disease and their close integration with agricultural practice are shown. The necessity for control experiments is not forgotten; nor is the important principle that the more we find out, the more there is to find out. It is for this insightful study of scientists at work that I most admire the film. The many ingenious devices by which its effect is apparently effortlessly produced will repay careful study by those interested in visual education. The feeling it gives of community of effort, of scientists and laboratory assistants and farmers tackling the liver fluke problem together, surely reflects the manner of making of the film, dependent as it must have been on exceptionally well-knit teamwork of film unit, technical advisers and performers. The result is a beautiful film.

M. L. Johnson.

This film was made by Basic Films for the Ministry of Agriculture; distributed by Central Office of Information; directed and edited by John Shearman.

The Bookshelf

Selected Works of I. V. Michurin. (Foreign Languages Publishing House, Moscow, 1949: pp. 496, 200 illustrations, 15*s.*)

THIS book deals with the work of Michurin, the celebrated pre-revolutionary plant breeder whose theories have been so much quoted in recent years. They have even been defined by Academician Lysenko as the foundation of a new system of thought, called 'Michurinism', which now appears to be the basis of plant breeding in Russia, while the town where he lived and laboured is now known as Michurinsk. The book is profusely illustrated. The first illustration on p. 4, the twenty-first on p. 87, and also the last, number 200 on p. 468, are all entitled "New Texas Raspberries". These attractive illustrations bring to mind inquiries I have received in recent years about new raspberries raised and grown in Russia with fruits over two inches long. On p. 423, however, we are told that the New Texas Raspberry was obtained by selection from seedlings of the loganberry. Hence the impressive fruits illustrated are not magnificent new raspberries but ordinary loganberries which have been known for nearly seventy years.

Michurin discusses at great length the involved question of the juvenile period of growth of fruit trees, grafting effects, and the influence of the stock upon the scion; he also gives an account of the origin of the so-called vegetable apple-pear hybrid 'Reinette Bergamotte'. I may recall that the Lysenko School have made much of this in recent years and claim it to be a classic example of so-called 'vegetative hybridisation'. Michurin obtained 'Reinette Bergamotte' from grafting an apple on to a pear stock and says the growth of the pear stock "became quite sickly in the spring of the second year after grafting", so to save the apple graft he layered and rooted it. In 1898 when five years old, the young layered tree bore its first fruits and Michurin says there was "great deviation in shape and size of the fruits beginning with the 1898 harvest and up to 1906". The first yield in 1898 had the appearance and shape of pears. Finally Michurin says "The seeds of the first fruits were round and large but did not germinate. In the following years the fruits changed somewhat, approximating the usual shape of apples." There is a drawing of the fruit of 'Reinette Bergamotte'; it is not very pear-like. I have seen apples very much more pear-shaped which have had nothing to do with grafting apples on to pears, and I cannot accept this as an example of vegetative hybridisation, nor can I find anything in the book which proves that there is such a thing as vegetative hybridisation.

Michurin's discussions of his so-called 'Mentors', and of the effects of environment are prolonged and seem to be largely, if not entirely, bound up with the juvenile period of growth, especially of fruit trees. In these accounts there is much with which those acquainted with the growing, breeding and grafting of plants and trees will not be able to agree.

Discussion on the inheritance of acquired characters is mainly philosophical and, as in the case of so-called vegetative hybridisation, there is nothing in the book which proves that acquired characters are inherited.

There is, however, much in this book which most biologists, at least most of those outside Russia, can accept. With such crops as rye, wheat, oats, peas, and millet, Michurin says "I consider the phenomenon of segregation of the parent types to be quite possible and that the Mendelian laws are applicable here in many details", and although he criticises the application of Mendel's laws in relation to the breeding of fruit trees, he nevertheless says "I by no means deny the merits of the Mendelian law. On the contrary I merely insist on the need to introduce amendment and addenda into it, for it is evident to everybody that his calculations are not applicable to cultivated varieties of fruiters (*sic*), for when crossing separate varieties of them, the structure of the hybrids is not due to the hereditary transmission of the direct and immediate progenitors, but in most cases of those belonging to the ancestors of the parent plants, unknown to the originator"; an addendum with which Mendel himself would certainly not have felt inclined to disagree.

Michurin further states "When investigating the application of Mendel's law to the hybridisation of cultivated varieties of fruit plants, I recommend that, as a beginning, the investigation be confined to observing the hereditary transmission of one or two characters, just as Mendel himself did in his work with peas." Michurin then lists suitable characters for this purpose, and then states, "Here there is great scope for applying the whole Mendelian calculus to the entire complex of characters of each hybrid." These references to Mendelism are extremely sound and far-sighted; and since they were written, much has been done in this and other countries, in the genetical analysis of fruits, precisely as Michurin advised.

Michurin pays tribute to the qualities of foreign varieties and states, "it is possible to improve our hardy local varieties by crossing them with foreign ones that had been raised in a warmer climate and which yield fruit of better quality as compared with our own, but are unable to resist our frosts".

After reading this book, and fully allowing for Michurin's criticisms of early Mendelism one is bound to ask whether Lysenko and his colleagues have been entirely honest with Michurin. They claim to be disciples of Michurin, but their violent and wholesale condemnation of Mendelism and Morganism, in Lysenko's *Soviet Biology*, and in the recent report of *The Moscow Conference on Genetics*, does not seem to fit with Michurin's teaching.

M. B. CRANE.

Nature Study Talks on Animals and Plants. By J. Macqueen Cowan. (Worcester. Littlebury, 1949, pp. 85, 6*s.*)

THIS book appears to be the permanent version of a series of nature talks broadcast for young persons. Consequently it is written in a straightforward simple style which is so well done that it would be very acceptable to many adults, especially those lacking previous experience in natural history. There are chapters headed: How animals move about; Mainly about feet; Animals that damage trees; Plants that animals avoid; How do plants travel?; Colour in flowers; On keeping a nature notebook.

Throughout the emphasis is upon personal observation, and the author skilfully encourages his readers to go out and make their own contribution to the common stock of knowledge. An admirable gift for the younger adolescent, and worthy of the bookbox of adult preparatory classes in natural history.

M. H. C.

The Geology of Lincolnshire. By Professor H. H. Swinnerton and Dr. P. E. Kent. (126 pp., 22 figures, 1 folding plate. Published by Lincolnshire Naturalists' Union, 1949, 5*s.* 6*d.*)

SOCIETIES concerned with field studies should make particular note of this excellent book, which is the first of a series to be published by the Lincolnshire Naturalists' Union. From its introductory chapters dealing with some of the fundamental principles of historical geology and rock formation, the joint authors have unfolded stage by stage the development of Lincolnshire's rocks and geological peculiarities. At no stage in their discourse do they obscure fundamental principles by the introduction of irrelevant data, but at the same time they have blended much new information for geologists in the form of maps and diagrams.

For example, among the 22 figures which illustrate the book is a sub-surface contour map of a buried land surface which existed over 170 million years ago. Furthermore, it shows the position of upstanding masses of carboniferous rocks adjacent to which rest the coal-bearing strata of the newly discovered coalfield of Lincolnshire. These maps have been constructed from the geological data provided by the deep boreholes put down by the D'Arcy Exploration Company in search for oil during the war. In this way Swinnerton and Kent have courted the interest of the specialist as well as that of the beginner in geological field-studies.

Consequently, this book is destined to serve the specialist as a factual introduction to the unsolved problems of Lincolnshire geology. On the other hand, it will unquestionably serve its intended purpose, as its clarity and interesting mode of presentation will encourage the would-be naturalist in the practice of geology in the field. For example, the principal fossils and rock-types will be easily identified by recourse to the excellent descriptions and illustrations, but at all times it will escape the fate of a textbook and remain the inseparable companion of the field naturalist in Lincolnshire.

On the other hand, the expert will be

roused by its many sweeping generalisations, and it may well serve to stimulate their interest in an area in which professional researches have lain dormant for too long. At the same time they reveal to the amateur the great need for local observations and the recording of temporary exposures and fossilised data which may or may not support the hypotheses outlined in this book. In short, the book demonstrates that the position of the amateur is as important now as in the past, and the concluding chapter of the book is a timely reminder of the great debt we owe to the unselfish painstaking work of these pioneers of field studies in Lincolnshire—F. H. Burton, Henry Preston, C. S. Carter, J. R. Farmery, and the Rev. C. R. Bower.

W. D. EVANS.

An Introduction to the Gas Turbine. By D. G. Shepherd. (London, Constable, 1949; pp. 387, 24*s*.)

WHILE a considerable amount of general descriptive matter concerning the gas turbine has been published, this book is the first comprehensive treatment of the science and technology of this powerful new prime mover. Its appearance is timely, for one of the dangers inherent in a rapidly developing branch of science is the growth of a number of specialists, each following his own particular line, which results in a spate of highly complex papers; it consequently becomes increasingly difficult to obtain an overall picture of the achievements and the problems to be overcome. The objective of the author is to fill "the gap between the largely descriptive matter for the general reader, and the technical papers of interest only to the specialist", and he has certainly succeeded in doing this.

Opening with a useful review of basic thermodynamics and the flow of gases (the latter including a rather too brief note on the important concept of vortex flow), the gas turbine is first introduced in terms of the cycles involved. Following this the compressor and turbine are discussed at some length, which leads to combustion and heat exchange. The remaining chapters cover existing plants, developments, applications, experimental methods and auxiliary equipment. There are four useful appendices. One very good feature is the inclusion at the end of each chapter of both a general bibliography and specific references, which enable the reader to pursue any particular topic in more detail.

For the reader with some technical background this book will be extremely valuable and even the non-technical reader will find much to interest him in the well-presented descriptive portions.

J. B.

Oxford Junior Encyclopedia (Oxford University Press, 1949). Vol. II—*Natural History* (486 pp., 30*s*.); Vol. III—*The Universe* (496 pp., 30*s*.)

THIS encyclopedia will contain 12 volumes when complete, of which these two cover mainly scientific subjects. Each volume is complete in itself in so far as it is arranged alphabetically.

A perusal of Vol. II gives an excellent indication of the high quality of the entries. The authors are well chosen, all of them being both knowledgeable and clear writers; for example, we find botanical subjects have been placed in the capable hands of L. J. F. Brimble and T. H. Hawkins. Great use is made of illustrations, to which over a quarter of the space is devoted. (In spite of this there are times when one feels that insufficient pictures have been used; for instance, the item on Gall Wasps shows only two galls.) The photographs are particularly good, as one would expect, since the editors have here called in such first-rate contributors as Harold Bastin, S. Beaufoy, Eric Hosking and G. K. Yeates. The line drawings could scarcely be bettered. It is only the colour plates about which one can have any doubts at all, and here one feels that a few of these plates are wasted because they show things of no particular interest (such as "Tropical Fish of Australian Seas").

These volumes will make a welcome addition to a children's library. As the coverage of Vol. III will not be obvious from its title, it is worth adding that it deals with many aspects of physics, astronomy, geology, geography and weather.

Wireless Simply Explained. By R. W. Hallows. (Chapman & Hall, London, 1949; pp. 255, 111 figs., 10*s*. 6*d*.)

Introduction to Modern Radio. By F. L. Poyser. (University Tutorial Press, London, 1949; pp. 232, 180 figs., 5*s*.)

BOTH authors succeed in providing a comprehensive work on the basic principles of wireless, and in adequately bridging the gap between the 'popular' and the more advanced kind of book. Each should equip the reader with a good general knowledge of the subject and provide a sound foundation for those who wish to proceed to more advanced reading.

The former author makes excellent use of appropriate analogy, and his book contains a wealth of simple numerical examples which should be of great value to the relatively non-mathematical reader. His description of basic radio components is written from the point of view of their application, but more space might with advantage have been given to practical details of these, together with illustrations. He succeeds in taking certain aspects of the subject to a more advanced stage, and yet with such thorough and painstaking explanation that the reader should follow the argument and appreciate the application of the knowledge acquired.

The latter author builds up his subject according to the sequence favoured by many of the more advanced text-books. This may be found to be an advantage to the reader who wishes to use this book as a step towards more difficult texts. He provides initially an outline of basic ideas in electrical theory, with a good description of radio components, supported by excellent illustrations.

In view of his claim that no previous knowledge of mathematics has been assumed, beyond that of elementary arithmetic, more worked numerical examples might well have been given at relevant points in the text.

A. A. R.

The Splendour That Was Egypt. By Dr. M. A. Murray. (London, Sidgwick & Jackson, 1949, 354 pp., with 97 plates and 24 line drawings, 30*s*.)

THIS book comprises a comprehensive survey of ancient Egyptian culture and civilisation, written mainly for the general reader. It is composed in an attractive style and well illustrated, the quality of most of the half-tones (including a few in colour) being excellent. Coptic survivals from ancient Egyptian culture are included. Dr. Murray is to be congratulated on the production of what is probably her greatest work on Egyptology.

The first two chapters provide a rapid survey of ancient Egypt from prehistoric times to the Ptolemaic period. On pages 11 and 330 the author's reluctance to abandon Petrie's long-dating chronology can be discerned. The remainder of the work contains chapters on social conditions, religion, art and science, and language and literature, all of them replete with suggestive ideas and stimulating observations.

The final chapter is on Flinders Petrie, who "out of the hobby of antiquarianism created the science of archaeology". "Without Petrie there would have been no archaeology" (p. 317). Petrie's greatness is (or should be) universally acknowledged; but what about Gen. Pitt Rivers? By 1877, when Petrie issued his first publication, Pitt Rivers was already fifty years of age and a Fellow of the Royal Society, with nearly twenty years of publications to his credit. Modern archaeology rests rather on twin foundations laid by Petrie and Pitt Rivers.

L. V. GRINSELL.

The Microscope. By Theodore Stephanides. (Faber, London, 1947; pp. 160, 20 illustrations, 10*s*. 6*d*.)

The Intelligent Use of the Microscope. By C. W. Olliver. (Chapman & Hall, London, 1947; pp. 182, 53 illustrations, 12*s*. 6*d*.)

Practical Microscopy. By L. C. Martin and B. K. Johnson. (Blackie, London, 1949; pp. 124, 90 plates and illustrations, 6*s*. 6*d*.)

EACH of these books, in its own way, sets out to equip the reader with the fundamentals of theoretical and practical microscopy. Apart, however, from their common purpose and from certain basic information which must be included in any book on the microscope, these three are refreshingly different from one another. The difference is one of approach and of emphasis and it is due to the fact that the authors themselves have impinged upon the microscope from three different directions.

Dr. Stephanides is a medical man. To him, therefore, the microscope is a tool used in medical and biological investigations. Having given a fairly extended description of the modern microscope stand and its optical equipment (including

a number of useful tests which may be applied when buying a second-hand instrument), he proceeds to set forth, systematically, the sequences of operations required to produce critical results with all normal combinations of objective and substage illuminator (both light- and dark-ground). Mention is made of binocular microscopes and there are sections on photomicrography and other means of recording observations and on methods of measuring. Oddly enough, counting methods are not mentioned.

Mr. Olliver is by profession an electrical engineer. His approach is that of the true amateur to whom microscopy is an end in itself. He sets out to furnish the reader with just sufficient optical theory to enable him to use a microscope efficiently without recourse to the kind of detailed directions given by Dr. Stephanides. There is an excellent chapter on illumination and useful sections on colour filters and photomicrography. Again the emphasis is on biological microscopy although mention is made of special types of stand used in metallurgy and mineralogy. This is an excellent book for the would-be microscopist who wishes to understand his instrument thoroughly before he uses it.

To Dr. Martin and Mr. Johnson (of the Technical Optics Department of Imperial College), the microscope is a piece of optical engineering—a tool made for other people to use. Their book is an attempt to ensure that those other people use it with understanding. This book goes deeper than do the other two into the applied optics of microscopy and assumes in the reader a firmer grasp of mathematics and of elementary optical theory. Here the metallurgical microscope is given due importance and there are good, if somewhat difficult, sections upon phase-contrast illumination, the use of plane-polarised light, and on ultra-violet microscopy. There is even a tailpiece on the electron microscope. The authors are, however, guilty of one error of judgment—the inclusion of a chapter on the preparation of specimens for microscopical examination. A few pages on so diverse and specialised a subject can do little to enlighten and much to mislead. As if to compensate for this lapse, however, this little book is very well illustrated.

R. P. H.

SCIENCE AND ADULT EDUCATION

Over 300 years ago Bacon wrote, "The true and lawful goal of science is that human life be endowed with new powers and inventions. The place of science in the education of the citizen is to enlist him in the constructive tasks of using the new powers and inventions wisely." The first dictum has been abundantly realised, but the second has been neglected. Adult education could do much to cultivate the approach to science advocated in the second part of the quotation from Bacon, and it is therefore a matter for great concern that in the field of voluntary adult education natural science studies constitute little more than 4½% of the total number of courses organised. Moreover, whilst the total number of students enrolled in such classes has risen fourfold since 1925–6, the percentage of classes in natural science has remained constant. Recent inquiry into this situation by a joint committee of the British Association for the Advancement of Science and the National Institute of Adult Education is consequently a matter of considerable social concern. The committee's report is published in *The Advancement of Science*, July 1949, and it contains facts and recommendations which should be the possession of every thoughtful scientific worker; for the educationalist and administrator it presents an urgent challenge concerning the adequacy and balance of the science taught in adult education.

Many difficulties confront those who would seek to increase the representation of science in adult education. Attendance is voluntary, and for the conduct of a successful course there must be sufficient skill and enthusiasm in the tutor to enable him to hold his audience for at least twelve or twenty-four weekly meetings. He will also discover his students to be a very mixed audience, some without secondary education, whilst others are well equipped in this respect. In addition the diversity of their interests is likely to be as wide as that of their abilities. Despite all this the tutor is under obligation to seek in all his teaching to lead his students into thought and practice consistent with the internal standards of the universities, who are active partners, with the Workers Educational Association and the Local Educational Authorities, in the sponsoring of these courses. Besides these difficulties the teacher of science must cope with such things as the unsuitability of the available accommodation to the conduct of practical work, and perhaps a total lack of equipment. But the two greatest obstacles to expansion arise in connexion with the organisation of classes. Unfamiliarity with science on the part of organisers and administrators has put science courses at a disadvantage when, in company with more familiar alternatives such as literature, history and economics, they have been set before potential students for their choice. Then, when science has been chosen, the administrator has hitherto been much more hardly pressed to find a tutor for the course than is the case for other subjects. Even allowing for the special circumstances, this is not to the credit of scientists as members of society.

Those scientific workers who have worked in the field of adult education are certain that a real demand exists amongst men and women to know more about science. Elsewhere this demand appears in the large numbers of good popular books and periodicals on scientific subjects that are regularly purchased. But it is a demand that requires cultivation before it can become sufficiently vocal to influence the provision of classes in adult education. For this cultivation to be fully fruitful it must be carried out by persons qualified in science. Thereafter, for the satisfaction of the demand, much more attention will have to be paid to the methods of instruction. Here there is a close parallel with science journalism. The difficulty is to be comprehensible and interesting without sacrifice of accuracy and soundness of judgment. Those who would give their aid in this service now have offered to them the assistance of short training courses in the aims, methods and special circumstances of adult education. These courses are being organised by several university extra-mural departments. Whilst in no way intended to turn out fully equipped adult tutors, they afford suitably qualified persons valuable opportunities for discussion and experiment in relation to teaching methods. It will probably be found necessary as the field opens up to recognise that there is a need for instruction to be given at three or more different levels. At the lowest level there will be the direct approach to the ordinary men and women of our community in terms of everyday experience and language, though even here more than one level may be found necessary in relation to differing degrees of literacy and interest. In the intermediate levels it is to be hoped that opportunities will be found for co-operating with the activities of local natural history societies and science clubs. At the highest level a demand may be found for courses of refresher type for graduates in their home towns, and for liaison courses for specialists to promote co-ordination of the increasing number of specialist activities.

Here then is a challenge to scientific workers to offer their co-operation in a service that should command their support, and that cannot prosper without their participation. The committee that has just reported recommends, as an indispensable preliminary to the expansion of science teaching, that the universities should appoint to their extra-mural staffs more people who are competent to teach and to organise classes in natural science. But the report also points out that this work cannot flourish unless a large number of suitable part-time tutors can be found from among science teachers and among scientists in industry and in research institutions. These must first be persuaded that here is a job to be done—different from, but not inferior to, their full-time occupation—and worthy of some of their scanty leisure time. Part-time tutors are paid, the fees being related in amount to experience and to the type of class involved, but reward to the tutor goes further than this through the broadening of his own perspective and horizons that comes from the preparation of his material and from its discussion with his students. Scientific workers desirous of participating in this campaign for the advancement of science in our social life should find entry possible through contact either with the extra-mural department of the nearest university, or with the district offices of the Workers Educational Association, the addresses of which can be secured from the national office of the Association at 38a, St. George's Drive, London, S.W.1.

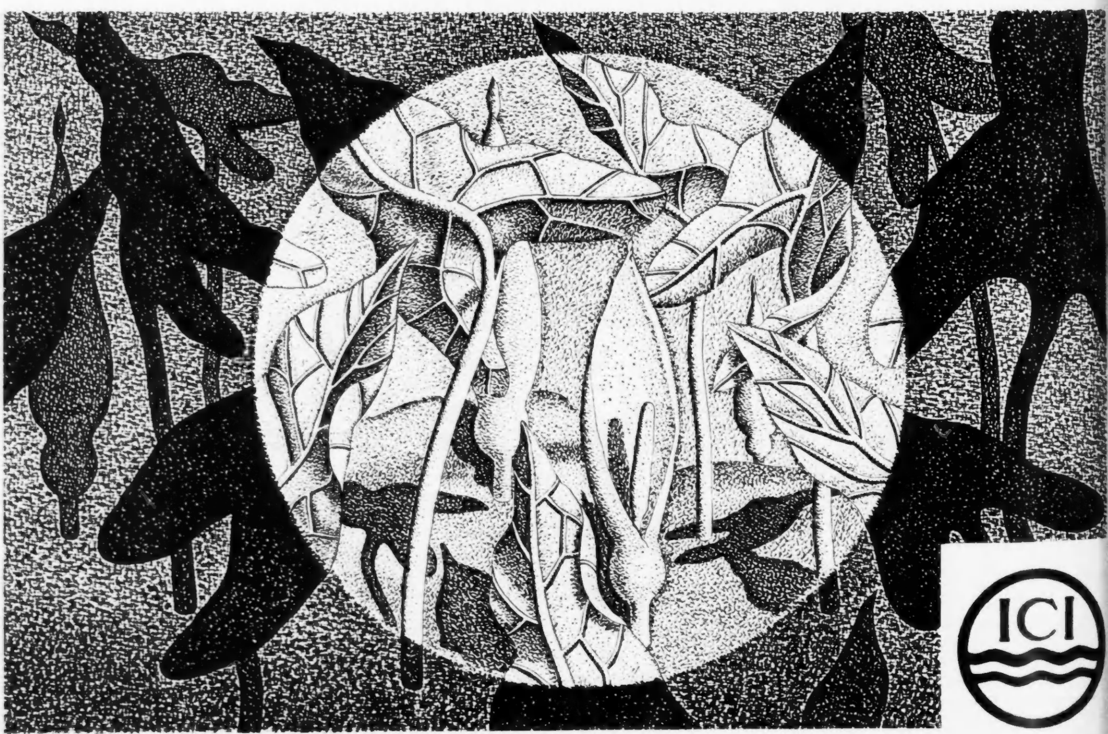
M. H. C.

Printed and Published in Great Britain by Jarrold & Sons, Ltd., Norwich. Editorial Offices: 244 High Holborn, W.C.1.

Infra-Red Photography

Astronomers today are able to photograph stars invisible to the eye, pilots can take aerial photographs through fog and haze, and detectives are able to expose forgeries of anything from banknotes to Old Masters — all by means of modern infra-red photography. Although infra-red rays are similar to the radiations which we call visible light, they cannot be seen by the human eye. Nevertheless, photographic plates can be made sensitive to these rays by treatment with certain dyes. These plates can then be used to photograph objects that are invisible. A boiling kettle, for example, can be photographed in complete darkness because of the infra-red rays which it emits. Infra-red rays can also be used to photograph distant landscapes or stars because they can penetrate the atmospheric haze which scatters normal light.

The first crude forerunner of the infra-red photograph was made just over a century ago by Sir John Herschel. He exposed to the sun's rays a piece of blackened paper, the reverse of which had been moistened with alcohol. But during the decade following the end of the first world war investigations by W. J. Pope and W. H. Mills and their collaborators at Cambridge contributed greatly to the systematic study and preparation of infra-red sensitising dyes.



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